



Constructing co-meaningfulness: collaborative learning across boundaries: studying innovation communities of designers and scientists

Ke Fang

► To cite this version:

Ke Fang. Constructing co-meaningfulness: collaborative learning across boundaries: studying innovation communities of designers and scientists. Education. Université Paris Cité, 2020. English. NNT : 2020UNIP5072 . tel-04097512

HAL Id: tel-04097512

<https://theses.hal.science/tel-04097512>

Submitted on 15 May 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Université de Paris

École doctorale Frontières de l'Innovation en Recherche et Éducation (FIRE) ED 474
Laboratoire Center for Research and Interdisciplinarity

Construire la Co-Meaningfulness: l'apprentissage collaboratif au-delà des frontières

Étudier les communautés d'innovation des designers et scientifiques

Constructing Co-Meaningfulness: Collaborative Learning Across
Boundaries

Studying Innovation Communities of Designers and Scientists

Par Ke FANG

Thèse de doctorat de Sociologie et Sciences de L'éducation

Dirigée par Sophie Pène
Et par Joël Chevrier

Présentée et soutenue publiquement le 18/09/2020

Devant un jury composé de:

François TADDEI, DR, Inserm, *Examineur (Président du jury)*

Mathias BÉJEAN, HDR, Université de Créteil, *Rapporteur*

Luping XU, Associate Professor, Tsinghua University, *Rapporteur*

Sophie PENE, Professeur Des Universités, Université De Paris, *Directrice*

Joël CHEVRIER, Professeur Des Universités, Université Grenoble 1 Joseph Fourier,
Codirecteur



Except where otherwise noted, this work is licensed under
<https://creativecommons.org/licenses/by-nd/3.0/fr/>

RÉSUMÉ

Cette thèse étudie un modèle émergent d'apprentissage collaboratif qui rapproche des designers et des scientifiques. Ces communautés d'innovation que nous nommons CoLAB se mettent en capacité de traiter des "Open Wicked Problems". Ces questions épineuses, expriment des problèmes urgents de notre temps qui résistent soit à une définition précise, soit à une solution rapide. On peut ranger parmi elles le développement de l'IA, les questions éthiques qui en découlent, les changements brutaux que la pandémie a d'ores et déjà provoqués sur les économies et le travail humain. Ce sujet est à rapprocher des initiatives d'apprentissage qui émergent dans les universités et les écoles, par exemple quand les étudiants en design et en sciences se regroupent en ateliers pour s'entraîner à la collaboration interdisciplinaire et font l'expérience du dépassement des limites de leurs connaissances et savoir-faire. Il est à noter que ces nouveaux formats d'expérimentation et de formation se répandent, comme une pédagogie des défis afin d'entraîner de jeunes scientifiques à tenter de résoudre ces "Open Wicked Problems".

Comment comprendre ces processus d'apprentissage? Quelles sont les obstacles à l'instauration de ces nouvelles approches, et comment les surmonter? Aborder le CoLAB, c'est-à-dire la collaboration au sein de communautés scientifiques et créatives occasionnelles ou durables, sous des aspects applicatifs se révèle essentiel. Ces perspectives concernent en effet des évolutions de l'éducation, et leur étude par les sciences de l'apprentissage.

L'auteur, qui se définit comme chercheur praticien explorant et développant le CoLAB, adopte la théorie constructiviste dite "Grounded Theory" pour l'analyse de données ethnographiques (observations, dialogues de conception) recueillies sur plusieurs années, au cours de sessions consacrées au développement de prototypes innovants réunissant des designers, des ingénieurs et des biologistes. Le codage et l'analyse des échanges ont mis au jour la notion de "Co-Meaningfulness" qui éclaire un résultat majeur du CoLAB: il apparaît que les participants ne communiquent pas seulement au niveau du "projet", dans une perspective de management, de prise de décision et d'efficacité. Ils négocient essentiellement sur la valeur de "sens" du projet. Leur apprentissage est un processus de "Co-Meaningfulness", c'est-à-dire de découverte et d'évaluation du sens que l'effectuation du projet représente pour chaque protagoniste. Ce sens, ce "Co-Meaningfulness", s'entend sous des aspects éthiques, scientifiques, d'utilité, de valeurs humanistes engagées. Il est étudié ici dans une perspective socio-cognitive et socioculturelle. Des outils notionnels et de représentation graphique éclairent les variétés de forme du "Co-Meaningfulness" du CoLAB. Ils rendent visibles et reconnaissables des processus non seulement implicites mais également encore peu reconnus socialement. Car ils abordent un mode de coordination souvent étouffé par la grammaire du management de la coopération. C'est pourquoi la a l'ambition d'ouvrir un territoire de recherche dédié à l'étude du Co-Meaningfulness qui concerne le management de l'innovation scientifique et créative.

Mots-clés: Co-Meaningfulness, apprentissage collaboratif, franchissement des frontières, Sciences de l'apprentissage, Wicked Problem, théorie fondée

ABSTRACT

This thesis studies an emerging collaborative learning model among innovation communities of designers and scientists, which we call the Collaborative Learning Across Boundaries for Open Wicked Problems, or simply: CoLAB. The “Open Wicked Problems” indicate the pressing problems of our time which resist either clear-cut definition or optimal solution, such as the fast-growing AI technology and its problematic ethics or the huge change of the economy and work model after the pandemic crisis. At the same time these problems are also “open” and accessible to learners who learn through trying to resolve them directly. New learning initiatives emerge in our universities and schools, e.g. design and science students aggregate in workshops to collaboratively learn across discipline and experience boundaries for attempting to resolve these “open wicked problems”.

How do we understand the process of the new learning? What are the key difficulties in the learning, and how to overcome them? Understanding CoLAB from a practice-based perspective is key to better facilitate this emerging model, which nowadays plays an increasingly significant role in education and the learning sciences. For this purpose, the author, as a researcher/practitioner of CoLAB, adopts the constructivist grounded theory based on an in-depth case study and a long-term ethnographic observation. From coding, categorizing and conceptualizing, we generate the concept of “Co-Meaningfulness” that casts light to the key process in CoLAB: that learners find it not enough just communicating at the level of “Project” they currently work on but they have to communicate and negotiate which part of the project is more “meaningful”. Their learning is essentially a process of not only constructing their joint project but also constructing their “Co-Meaningfulness”. The process of constructing “Co-Meaningfulness” is then studied with both socio-cognitive and socio-cultural perspectives, which generates a framework of conceptual and visual tools for analyzing CoLAB. The concept and framework of Co-Meaningfulness emerges and visualizes the underlying Co-Meaningfulness process of CoLAB, making the “invisible” “visible”. Basing on a practice-rooted perspective and a structured analysis, this thesis proposes a novel way to understand and analyze CoLAB which opens opportunities for future research.

Key words: Co-Meaningfulness, Collaborative Learning, Boundary-crossing, Learning Sciences, Wicked Problem, Grounded Theory

ACKNOWLEDGMENTS

My Ph.D. life was like a second life to me: Moving from China to France, immersing in a different culture, using a second language, changing from design and engineering to social science. These five years changed me from a student to a passionate education practitioner and researcher, thanks to enormous help from friends, mentors, colleagues and families.

I would like to first thank my supervisors: Sophie Pène and Jöel Chevrier, for their generous guidance and help in both academics and life. I can memorize many moments in my Ph.D. life when they encouraged and helped me to get through hardships. Sophie and Jöel are not only supervisors to my thesis, but also mentors and friends who kept giving me courage, company and inspiration. Thank you very much and I learned a lot from both of you that I know will be invaluable for the rest of my life!

I very much thank my friends and colleagues: Juanma, Lena, Wanni, Yao and Ying. I treasure so much the time when we worked together trying to innovate education. To me, these experiences are not separated from the final thesis, but truly an essential part. I would like to thank all the organizers, mentors and participants in the various activities. I also learned a lot from all of them in the workshops, in the practicums, in the debates, in the brainstorming and in the pizza and beer sessions!

I thank all the innovative communities and initiatives during the past years, namely the CRI, the OSS, the Open FIESTA, the SDGo. I thank all their sponsors: François, Luping, Jing and Xiao, etc. Your sponsorship makes this research possible.

I would like to thank all the juries of my thesis, Mathias Béjean, Luping Xu, Valerie Chanal, François Taddei, and Antonella Tufano, for their very insightful remarks and advice.

I thank my families who have been so supportive all along, especially my wife Ruoshan, who joined this expedition with me. Your support is always the warmest thing I can have.

Finally, I thank those who have been working so hard and keeping us safe in the time of the pandemic. Your sacrifices urge us to create a more sustainable future.

TABLE OF CONTENT

RÉSUMÉ	1
ABSTRACT	2
ACKNOWLEDGMENTS	3
TABLE OF CONTENT	4
FOREWORD	7
INTRODUCTION	9
1. New Problems of the World – the Open Wicked Problems	9
2. Challenges of Learning in the Era of Open Wicked Problems	16
3. The Emerging New Learning Model: CoLAB (Collaborative Learning Across Boundaries for Open Wicked Problems)	22
4. Research Motivations, Questions and Key Findings	41
5. Thesis Structure	48
PART I. LITERATURE REVIEW AND METHODOLOGY	53
Chapter 1. Collaborative Learning	54
1.1 The “Cooperative Learning” Perspective	56
1.2 The “Socio-Cognitive” Perspective	64
1.3 The “Socio-Cultural” Perspective	68
Chapter 2. Learning Across Boundaries	77
2.1 Interdisciplinary Learning	78
2.2 Expansive Learning	81
Chapter 3. Qualitative Research Methodology	88
3.1 The Constructivist Qualitative Research Paradigm	88
3.2 Research Methodology Rationale	93
Chapter 4. Constructivist Grounded Theory (C-GT)	96
4.1 Grounded Theory	96
4.2 Constructivist Grounded Theory (C-GT) Method	100
PART II. THE DISCOVERY OF CO-MEANINGFULNESS IN CoLAB	110
Chapter 5. The Socio-cognitive Perspective of CoLAB	110
5.1 Introduction to the Socio-cognitive Perspective of CoLAB	110
5.2 The Case of “Jumping Video”	113
Chapter 6. Coding and the Emergence of the “Co-Meaningfulness” Category 	119
6.1 Initial and Focused Coding	119

6.2 Analyzing One Challenge and the Category of “Co-Meaningfulness”	130
Chapter 7. Co-Meaningfulness and its Trajectories	138
7.1 Further Coding for Categorizing Co-Meaningfulness	138
7.2 The Co-Meaningfulness Quadrant Map.....	152
Chapter 8. The Socio-Cultural Perspective of CoLAB and Co-Meaningfulness	160
8.1 Introduction of the Socio-Cultural Perspective of CoLAB and Co-Meaningfulness.	160
8.2 Co-lab Bio-design Workshop Series	165
8.3 Core organizers and the Learning Community	168
Chapter 9. “Evoking” and “Applying”: the Basic Pattern	171
9.1 Evoking Socio-historical Project.....	172
9.2 Applying Socio-cultural Meaning	176
9.3 Categories of Evoking and Applying	177
Chapter 10. “Prioritizing”: the Underlying Pattern	190
10.1 The Multiple Potential P/M (Project/Meaning)	191
10.2 “Prioritizing” : Selecting P/M from the multiple potential	199
10.3 Evoking, Applying, Prioritizing and Meaningfulness	205
Chapter 11. Evoking, Applying and Prioritizing and the Co-Meaningfulness Trajectory	207
11.1 Three levels of Co-Meaningfulness and its properties	210
11.2 Generating Co-Meaningfulness Trajectory with the Three-level Framework	213
Chapter 12. Conclusion: the Grounded Theory of Co-Meaningfulness	218
12.1 The Socio-cognitive Perspective of Co-Meaningfulness	220
12.2 The Socio-cultural Perspective of Co-Meaningfulness	223
CONCLUSIONS	227
1.Thesis Summary: Constructing Co-Meaningfulness in CoLAB	227
2.The Key Contributions of “Co-Meaningfulness”	229
3.Prospect of Using “Co-Meaningfulness”	235
APPENDIX	241
A. Project of “Jumping Video”	242
A1. Conversation and Coding	242
A2. Interview and Coding	270
A3. Memo and Coding	281
B. Project of “DNAish Food”	298
B1. Chris’s background	298
B2 Matt’s motivation	301
B3 What’s interdisciplinarity	304
B4 Lina’s design examples	308
B5 Does Science Communication Need Emotion	310
B6 Labelling DNA content.....	312

C. Project of “Chrom-air attack”	316
C1 Interaction Design – Reinventing the Rules	316
C2. The Metaphor of Weapon.....	321
C3. The start of the idea	327
C4. Denqing’s Bubble	329
C5. Scientific and Romantic.....	332
C6. The science fiction.....	334
D. Co-Meaningfulness Trajectory Examples.....	336
D1. Co-Meaningfulness Trajectory Example of B2	336
D2. Co-Meaningfulness Trajectory Example of B3	337
D3. Co-Meaningfulness Trajectory Example of B5	338
D4. Co-Meaningfulness Trajectory Example of B6	340
D5. Co-Meaningfulness Trajectory Example of C3-6.....	341
BIBLIOGRAPHY	342

FOREWORD

We enter an era when the pressing problems are complex and entangled, such as the climate challenge and the AI technology and ethics. These problems, as some refer as the “wicked problems” resisting either clear-cut definitions or optimal solutions (Rittel & Webber, 1973), are now “open wicked problems” that are open to the “laymen”, the students, the common citizens, who are actively involved in learning and solving them. New learning initiatives emerge where students learn through facing and making attempts to solve these problems directly. Unlike the traditional vertical learning model, these new learning initiatives enter our university and school pedagogy in format of events such as workshops, bootcamps, summer schools, competitions, etc. Besides “open wicked problems” oriented, these learning initiatives feature “boundary-crossing collaboration”, as in real world no single person or perspective can solve these problems alone. This thesis specifically focuses on this new learning model, by which we call the CoLAB (Collaborative Learning Across Boundaries), in the era of “open wicked problems”.

As a researcher practitioner, I am interested in both understanding and better facilitating CoLAB. Practice-based understanding is essential as the new learning is by itself a wicked problem, resisting the simple theoretically derived understanding. The “openness” of the new learning invites a divergent practitioner community, which urgently calls for understandable research as well as pragmatic tools and guidance to better facilitate their practice. The practiced based understanding and pragmatic need are the two motivations for our thesis. To reach this end, we adopt a practice-based research paradigm by deeply involving in participating and organizing CoLAB, which well equips us with insider practical experiences. We use the constructivist grounded theory to qualitatively analyze our participant observation, so that the research tells the complexity of CoLAB, rather than reducing it.

Our key result develops from our initial coding of “Meaningfulness” in a case study, which later leads to the discovery of “Co-Meaningfulness”, the key concept in this thesis. In Co-LAB, learners seem to discuss and argue on their “Project” at hand, but potentially they are negotiating how the project is meaningful in divergent ways. To coordinate the different meaningfulness and to build a “Co-Meaningfulness” is the underlying but essential process in CoLAB. With further analysis, we extract two key properties of Co-Meaningfulness: the Project-Meaningfulness Intensity (P-M Intensity) and the Meaningfulness-Meaningfulness Coherence (M-M Coherence) with which we build a quadrant map and anchor the learning process with the Co-Meaningfulness trajectory. We further sample a long term observation of a

series of CoLAB workshops aiming to understand CoLAB and Co-Meaningfulness in the socio-cultural perspective. From further coding and analyzing, we find that individual “Meaningfulness” is built through “evoking,” “applying” and “prioritizing”: the learner prioritizes and evokes a past experience and applies a similar social meaning into the current “Project”. Co-Meaningfulness is then constructed when multiple learners evoke, apply and prioritize based on their socio-historical background and the then learning situation. The development of Co-Meaningfulness is a process where learners constantly re-prioritize, re-evoke and re-apply, adapting their own meaningfulness to exchange with the current Co-Meaningfulness.

The “Co-Meaningfulness” is a framework based on our coding and grounded theory with concepts, properties and visualization tools. The main contribution is two-fold: first, it is an easy understandable tool to identify the key challenges in CoLAB during and after CoLAB, which will help practitioners to improve their practice; second, from the developmental perspective, “Co-Meaningfulness” from one CoLAB will enter the learners’ “library” of “Project” and “Meaningfulness” for them to evoke and apply in the next CoLAB. Understanding this developmental role of “Co-Meaningfulness” will help us better catalyze the development of individual and the community of CoLAB.

INTRODUCTION

The nowadays world is facing unprecedented changes that have great influence on learning and education. One of the most salient change of our time is that the pressing problems are no longer the “tame” problems with clear-cut definitions and optimized solutions. Instead, they are complex problems which are entangled with many different factors and easily accessible to everyone (e.g. ecological sustainability, disruptive technology such as AI and its ethics, climate change, etc.). These new problems challenge the traditional model of learning, and also urges the emergence of new learning models.

There are three-fold background of our thesis: First, The new problems of the world are “open wicked problems”, which are ill-defined, complex in its nature, entangled with multiple factors and accessible to everyone. Second, the open wicked problems bring challenges to our traditional learning and education in multiple ways. Third, In responding the challenge of open wicked problem, new learning models are emerging. Open-wicked-problem based learning, collaborative learning, and boundary-crossing learning are the key features of the new learning model.

This thesis is motivated to study the new model of learning that arise to face the new open wicked problems. The general motivation of this thesis is to first provide a practice-based research with an insider understanding of the new learning model, and second to provide analytical tools and guidance for practitioners and learners who practice the new model of learning.

In the INTRODUCTION, we first present the general research background in the first three sections, and then our research motivations, questions and key findings in the fourth section, followed by a thesis structure section which overviews all the parts of the whole thesis.

1. New Problems of the World – the Open Wicked Problems

The Story of Ziqi

In a remote countryside in Sichuan province, Southwest China, a young lady is doing her housework. She has some cotton at hand, which she just collected from her own farm. Six months ago, on the day of Guyu, one of the 24 festivals in traditional Chinese calendar, she planted the cotton seeds in an early spring rain. Now, in the late autumn, the cotton is ready, and she is

preparing to make a quilt for her grandma. One trouble emerges: the bamboo bow for fluffing the cotton is broken, but a trouble like this cannot trap our versatile lady. She picks up some new bamboo sticks and fixes the tool, just like an old-time craftswoman would do. She will need the bow tonight, when her grandma will accompany her fluffing the cotton and making the quilt, in the countryside moonlight.

The lady seems to live in an old-fashioned life, she plants and collects the cotton, crafts the tool and makes the quilt all by herself. Her life looks calm, isolated and free, in a secret corner of Southwest China.

So might her over 9 million Youtube subscribers believe or, more precisely, wish to believe.

The lady is named Li Ziqi. The fact is, she lives with her grandma, does all the work we say, but not isolated with the world. Instead, one might say she is just the opposite of an isolated figure, but a key opinion leader and a cyber celebrity. She has 9 million followers on Youtube. Her videos are well made with traditional Chinese crafting, cooking, farming, clothes making, etc. We see very often a calm and beautiful countryside with only Ziqi doing the farm work. In 2019, her story was heatedly debated as an example of Chinese culture exporting to the western world, as many of her subscribers are westerners who loves the calm life she appears to live in. There are supports, skepticism as well as grim criticism questioning the cultural export intention. The problem is even more sensitive given the gap between Chinese and the western social media, mainstream public opinion and sociopolitical ideologies. Ziqi must deal with it, balancing the public sentiment while keeping producing her content with the feedback she received. The world also has to deal with it: the phenomenon of Ziqi, which never appeared before, leaves a challenge and opportunity for inter-cultural exchange, and probably more deeply, for the clash between obviously gapped Chinese and western media, public value and opinion, and ideologies in general, in the 21st century.

Despite of the controversy, Li Ziqi is a big success. She attracts so many foreign subscribers on a foreign online platform (which is not even accessible in China), directly influencing millions of people speaking so many languages that she might not know. The popularity makes the seemingly isolated life only one side of the coin. Her life is not isolated, but closely connected to her audience and the public internationally. The influence is mutual: Ziqi also has to communicate in one way or another to the audience, live with the huge impact she makes (including responding to the controversial debate on cultural export) and become both a professional youtuber and the lady working in the farm.

Not only Ziqi, the world is embracing growing entanglement and complexity, manifested in its every connected subject and object. Ziqi's story is just one example showing how profound connectivity and complexity can thrive from showcasing the opposite: an isolated and simple life. The seemingly isolation intentionally yet surprisingly results in profound connectivity, and the seemingly simplicity conveys huge complexity. And the world is driving towards that direction: simplicity and isolation diminishes, while complexity and connectivity pervades. The entanglement and hybridization is the new trend.

The entanglement and hybridization have infiltrated every aspect of our lives. In <<Chapter 1.1 "The Proliferation of Hybrids">> of his book <<We have never been modern>>, Bruno Latour wrote:

"On page four of my daily newspaper, I learn that the measurements taken above the Antarctic are not good this year: the hole in the ozone layer is growing ominously larger. Reading on, I turn from upper-atmosphere chemists to Chief Executive Officers of Atochem and Monsanto, companies that are modifying their assembly lines in order to replace the innocent chlorofluorocarbons, accused of crimes against the ecosphere. A few paragraphs later, I come across heads of state of major industrialized countries who are getting involved with chemistry, refrigerators, aerosols and inert gases.

The same article mixes together chemical reactions and political reactions. A single thread links the most esoteric sciences and the most sordid politics, the most distant sky and some factory in the Lyon suburbs, dangers on a global scale and the impending local elections or the next board meeting. The horizons, the stakes, the time frames, the actors - none of these is commensurable, yet there they are, caught up in the same story. For the others are multiplying, those hybrid articles that sketch out imbroglios of science, politics, economy, law, religion, technology, fiction. ... "

(Latour, 1993, pp. 1-2)

The newspaper story of ecosphere damage he read reached from chemistry to politics, from economy to law, religion etc. The story is not a fiction that makes up plausible links, it is the reality with authentic entanglement, as Latour wrote: "these imbroglios do the mixing," ... "they weave our world together!" (Latour, 1993, p.3). Both Ziqi's controversy and Latour's reading present new problems of our time. There are not problems people know how to solve with existing and fixed knowledge or knowledge frame, but ill-defined problems whose solution requires effective and wise integration of science, technology, society and life.

The “Open Wicked Problems”

As early as in the 1970s, scholars have noticed the rise of such problems in the field of social policy and urban planning. Rittel and Webber first coined the concept of “*Wicked Problems*”, by which they indicated problems that are “no meaningfully correct or false”, have “no sense to talk about optimal solution” and have “no agreed definition” (Rittel & Webber, 1973). These problems emerged when there appeared a conflict between social protest of the “laity” and policy making of the professionals. The problems, such as equity in policy making, were not “tame” - definable, understandable or consensual. Rittel and Webber (1973) challenged the modern tool such as professionalism based on traditional science and engineering in resolving such problems, proposing that traditional tools are designed for well defined “efficiency” problems, such as optimizing resources, with a “planned” system. But for the “wicked problems”, the goals are uncertain; the definitions are inseparable to the solutions; the input and output factors are intertwined; and even the historical sense of progress is “eroded”. A perfect “planned system is unattainable” and it is “even questionable if such a system is desirable” (Rittel & Webber, 1973, p.159). Rittel and Webber (1973) further summarized the ten properties of wicked problems to distinguish them from classical problems.¹

Latour’s problem of ecosphere damage can be seen as a typical wicked problem: its definition is elusive, depending on the perspectives of possible solutions; different disciplines of knowledge are useful but one cannot exhaust all useful knowledge and plan for a perfect solution; any attempt in solving the

-
- ¹ 1. There is no definitive formulation of a wicked problem.
2. Wicked problems have no stopping rules
3. Solutions to wicked problems cannot be true or false, only good or bad
4. There is no immediate and ultimate test of a solution to a wicked problem
5. Every solution to a wicked problem is a “one-shot operation”; because there is no opportunity to learn by trial-and-error, every attempt counts significantly.
6. Wicked problems do not have a enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan.
7. Every wicked problem is essentially unique.
8. Every wicked problem can be considered to be a symptom of another problem
9. The existence of a discrepancy representing a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem’s resolution
10. The Planner has no right to be wrong.
(pp. 161-166)

problem will have consequences, and the problem evolves as we solve it; finally, the different perspectives of the problem, from chemistry to biology, politics and business are so intertwined that we cannot just “divide and conquer”.

Back then, Rittel and Webber (1973) did not know if the phenomenon of “Wicked Problems” will last and become the significant problems of the world. But as we have experienced the huge change of the world during the past decades, featured by the fast growth of science and digital technology and the dramatic change of social life, the significance of the “wicked problems” only increase. Climate change, AI development and ethics, cyber and data security, pandemics, globalization and anti-globalization, social media and disinformation, Sustainable Development Goals(SDGs)² problems - to name a few of the pressing “wicked problems” of our time.

Though the “wicked” nature of the problems persist, which is meant for the opposite of “benign” or “tame”, nowadays the problems present new features. The most salient new feature is the active participation of the “laity”: the general public constantly contributes to forming and solving the problem, and their role in the wicked problems changes from *peripheral and passive* to *central and active*.

When Rittel and Webber (1973) introduced the concept “wicked problem”, the focus is still for the researchers and policy makers to realize the emergence of the new kinds of problems. The underlying intention is still for policy makers, researchers and professionals to solve/resolve the problems caused by the complexity of society. These policy makers, researchers and professionals are assumed to play the central and subject role whereas the public and society in the peripheral and object position. Nowadays, this premise is under question. With the rapid development of information technology, everyone can access vast information with which everyone understands one facet of the wicked problem. Then the invention of social media and online co-working open platform³ greatly facilitates everyone to collectively share knowledge, construct project, and solve/resolve the wicked problems. The participation of the “laity” is not trivial to these problems. In Ziqi’s case, the power is almost reversed: many professional diplomats or researchers in culture communication do not have the kind of influence as Ziqi does. Yet Ziqi is just an ordinary youtuber broadcasting her life. She might not know very much about the science or the professional practice of cultural communication, but she is put in the center of the issue, playing a key and active role. So do many

² More details on the SDGs: <https://sustainabledevelopment.un.org/?menu=1300>

³ e.g. knowledge sharing platform such as the Wikipedia, experience sharing platform such as the Instructables

of us who consciously or unconsciously contribute to solving the wicked problems.

We will refer to the kind of “wicked problems” that everyone can actively access and contribute to as “*Open Wicked Problems*”, which is the new form of the pressing problems in the current world. The “*Open Wicked Problems*” are pervasive: from Brexit to US-China rival, from climate change to AI ethics, from pandemic to cyber security, from new entrainment like TikTok to new application of cutting edge biotechnology. Solving problems of this kind not only relies on the work of researchers, the professionals, the government, the enterprises, but also students, makers, entrepreneurs and all of us who tweet, who mobilize, who speak, who influence and who empower.

For example, using AI to analyze user data for multiple purpose (e.g. recommendation, advertisement, surveillance, behavior analysis, etc.) has become more and more popular, and how to use AI in an ethical and responsible way is one of the pressing open wicked problems of today. It is more than an “efficacy” problem to be solved with algorithm, but a design and policy problem. When AI is playing an increasing role in not only what to buy but also whom to vote, the ethics of using AI is not neglectable. Who should own the data and have the right to analyze the data? When it is entirely up to the giant tech companies, there might be an interest to inappropriately use the data for private benefit (e.g. the Facebook data privacy scandal with Cambridge Analytica). But if no one should have the right to collect and analyze the data, we might lose the opportunity to wisely use the AI analytical power for better understanding the public and for better policy making. Many countries believe that they should develop this ability as a key competitive power in the 21st century, therefore completely abandoning the technology does not seem to be an option. Then it is important for the government to understand the problem and make policy to ensure appropriate use of the data for public benefit. But whether the political choice of government-company collaboration is ethical and responsible is also questionable. In 2018, the collaboration between Microsoft and the U.S. Immigration and Customs Enforcement (ICE) irritated Microsoft employees when they found out their technology tools, such as face recognition APIs, are used to separate the immigrant children from their families. Many employees threatened to leave the company which pushed the change of the AI algorithm of the ICE project. The political stance of the employees of the tech companies are also part of the problem.

The problem of AI ethics and responsibility is also largely influenced by the public opinion. In Europe, there is considerable concern of abusing private data by companies or by the government. The European General Data Protection Regulation (GDPR) aims to protect the privacy of individuals by

ensuring the individual's control of their personal data. In China, the concern is much less. The use of face recognition in the street is accepted without much challenge. The CEO of Baidu, the biggest Chinese search engine, once said in public that he believed the Chinese people are willing to compromise privacy for convenience. Only the most apparently inappropriate scenario of AI use is challenged: for example, one of the face recognition project claims that they can detect children who are not happy or absent-minded in class so that the teacher can "correct" them with the facilitation of this technology. The scenario is widely criticized as people worry it will harm the children's mental health when they know their every face expression will be recognized and graded. The backfire of public opinion forces the company to rapidly withdraw their project.

Besides the entanglement of companies, government and the public, this problem is also greatly impacted by the "Black-Swan Events". At the end of 2019, an epidemic heavily hit China which later develops into the worst global pandemic in one century. Billions people's lives are affected, both by the illness itself and by the economy shutdown. Many governments have to enforce strict measurement for social distancing, and the use of AI gives them powerful tools for that purpose. In China, technology giants Alibaba and TenCent soon developed a health barcode that can determine the possibility that you have been exposed to virus, based on your digital "footprint". The barcode will give a green light to whom they believe is less likely to be exposed and red light to the others. When cities with low risk started to lift the lockdown, the barcode helped to determine whom should be the first to go back to work, to use public transportation and to go to public spaces, etc. Although the measurements are for the emerging crisis, we do not know if it will become the new norm after the pandemic. The pandemic has inevitable impact on our future including how we regard the AI technology and its use. To appropriately deploy AI is extremely complex and entangled, and it is not just problems of government and tech giants, but also questions for every one of us who uses and contribute to both the problems and the solutions.

The collective intelligence and collective wisdom is more than ever an urging demand for the era of "Open Wicked Problems". Ziqi along with every one of us is empowered and obliged to create a better future together for this complex and entangled world.

2. Challenges of Learning in the Era of Open Wicked

Problems

As reaching collective intelligence and wisdom for open wicked problems becomes an urging task, our current learning and education system confronts profound challenges.

The Tradition Paradigm of Science and Engineering

The open wicked problems challenge the tradition paradigm of science and engineering. The contradiction between the complexity of “wicked problems” and our cognitive limits to solving them is partially due to the learning paradigm that we inherit from the traditional science and engineering, as Rittel and Webber (1973) wrote:

“One reason the publics have been attacking the social professions, we believe, is that the cognitive and occupational styles of the professions – mimicking the cognitive style and occupational styles of engineering – have just not worked on a wide array of social problems” (p.160)

The traditional cognitive and occupational style relies on a unitary and acute objective, on the process of planning and testing, on the closed system instead of an open complex system. But this learning and knowledge creating paradigm will face immediate problems in front of the open wicked problems.

Every open wicked problem is unique, and everyone with a distinct perspective enhances this uniqueness. In terms of cyber and data security, a traditional problem definition might be how to design a perfect system that prevents hacking or any form of sabotage to the data security. But an open wicked problem perspective of the issue might not agree with the unitary objective. One might question if such a perfect system is good for social good; who owns the key to the perfect fortitude of data; even if data is secured, does the user feel as much secured; who owns the data and has the right to define and change the level of security, etc. When we take into consideration various perspectives, including enterprise’s interests, user’s right and privacy, power and decision making, the problem’s definition becomes elusive. The traditional objective needs to incorporate with the open wicked problem perspectives in defining the problems.

The traditional process of testing does not work. Every attempt of solving or resolving the problem will inevitably bring consequences that might change the problem itself (Rittel & Webber, 1973). The tradition style of science and

engineering can test many times in order to learn and create knowledge, but for the open wicked problems, the testing is just a one-time shot. When Ziqi reacts to the controversy of cultural exportation (see Liqi's controversy in INTRODUCTION.1), her reaction will change the perception of the public which might alleviate, intensify or even entirely redirect the problem. But she cannot withdraw and announce that reaction to be a "testing". The experience and knowledge learned in open wicked problems must be adapted to some type of more sophisticated form of knowledge but not immediately applied to the same problem assuming the condition will be the same. The way testing works for traditional learning does not work for open wicked problems.

The open wicked problem is an open system with complex and unenumerable set of interconnected input and output (Rittel & Webber, 1973). A typical traditional problem sets up the frame of inputs and rules so that the outputs are the results from the problem solving. The open wicked problems do not follow this pattern. The output can influence a larger social context so that the input and the rules are changed. Or the output may connect to external factors that significantly shift the center of the problem. For example, a typical traditional problem might be to optimize the bike recycling efficiency for city bike sharing system, according to the distribution of population and riding routes. But the improved efficiency and convenience in turn results in massive broken even sabotaged bikes so that efficiency does not matter that much. Instead, encouraging users to report broken bikes becomes the center of the problem. One might also consider the campaign and design to protect the bikes as one of the factors. We need to cope with the complexity and openness of the open wicked problems.

To conclude, the first challenge owes to the properties of the open wicked problems themselves – plural and ambiguous objective, unable to test, open and intertwined inputs and outputs. Professionalism and its associated science and engineering learning paradigm is useful but not sufficient in facing the new problems.

One of the key improvements to the learning paradigm is to incorporate the rationality-based learning with problem-based learning or project-based learning, which has been started in many areas where complex problems pervade, e.g. in medical and management school. The introduction of problem-based learning, especially open wicked problem-based learning, will complement the classical problem-solving paradigm.

The Separation and Specialization of Knowledge

The open wicked problems challenge the separation and specialization of knowledge. The separation and specification of knowledge is one of the major features of the current learning. Latour (1992) rhetorically explained the divide between nature science and social science and research: “They have cut the Gordian knot with a well-honed sword. The shaft is broken : on the left, they have put knowledge of things; on the right, power and human politics (p.3)”. But the open wicked problems are demanding increasing holism “to retie the Gordian knot by crisscrossing.” (p.3)

The major form that results in the separation and specialization of today’s learning and education is the disciplinary divide. But any discipline of knowledge alone is not enough in solving the open wicked problems. Learners need to collaborate and wisely integrate the knowledge they gain in their respective disciplinary learning. Interdisciplinarity becomes an often-referenced approach to solve open wicked problems.

Understanding the historical reasons for disciplinarity and interdisciplinarity can help us understand this challenge. Disciplines form with different historical reasons: some based on common theoretical inquiries, some with similar methodologies, and others with common problems (Scott, 2016). Once the discipline is mature, the theoretical thinking, methodology and the problem frame make it distinguishable from other disciplines of knowledge. A discipline will evolve with complex academic efforts, but it will not be adequately agile to adapt to emerging problems like the open wicked problems as we discussed. That is why many discoveries are likely to happen on the boundaries between disciplines where new techniques, perspectives and ideas clash (Rylance, 2015).

Therefore, interdisciplinary research and education has been active in universities and research institutes. But how to implement interdisciplinary is not that easy. The cognitive and institutional obstacles are two of the main reasons for inefficient interdisciplinary learning (MacLeod, 2018). In one of his interviews, Harvey Graff, who did a historical review of 12 case studies of interdisciplinary efforts (Graff, 2015), explained that interdisciplines are historically not opposed to disciplines but the two are interdependent and co-existent:

“one myth is that interdisciplinarity is based on the “integration” of disciplines or requires “mastery” of multiple disciplines. Another is that there is one path toward interdisciplinarity – a large group and expensive science. As the case studies in my book demonstrate, there is no one

formula that has a higher chance for success. Nor is interdisciplinarity new. It is part of the history of the modern research university and the development of disciplines from the late nineteenth century on. Too often we frame the disciplines and interdisciplinarity as opposed; the reality is that one depends upon the other.” (*The undisciplinarian: A view From the Bridge*, n.d.)

Therefore, the real drive for interdiscipline is the emerging “problem”, which should be put in the center of interdisciplinarity and be paid closely attention to in reaching meaningful collaboration with better communication, as Graff stated:

“interdisciplinary research as what emerges from the effort to develop new answers to questions (or approaches to problems) that require elements from different disciplines, subdisciplines and fields. The questions and problems are central.... Researchers, institutions and funding agencies need to be more honest and modest. Forsake endless typologies (transdisciplinary, meta-disciplinary) and focus instead on specific questions and problems. Also, consider the physical and social organization of research. Interdisciplinary efforts do put much greater demands on the quality of communication.” (*The undisciplinarian: A view From the Bridge*, n.d.)

The open wicked problems in its nature challenge the disciplinary boundary and push interdisciplinary learning. Moreover, as Graff pointed out, the problems are not only the reason why disciplines should agilely cross boundary but also the reason why different disciplines CAN overcome the barriers by focusing on the problems. However the interdisciplinary efforts are not easy and many have reported the hurdles in crossing the boundaries(MacLeod, 2018)(Evans & Marvin, 2006)(Rhoten, 2004)(Pohl, 2005). There exists a great challenge in understanding how to cross the boundary of disciplines in practice.

The Subject, the Scenario and the Purpose of Learning

The open wicked problems challenge the subject, the scenario and the purpose of learning. Who learns? Where do they learn? Why do they learn? The open wicked problems, especially its “open” nature (see INTRODUCTION.1), challenge the most fundamental questions of learning. Everyone now has considerate access to vast information in order to learn knowledge, and they also have the digital tools to widely share their knowledge and skills. These are the digital infrastructure with which everyone has the potential to learn/teach and to contribute to solving the open wicked problems. The learning activity in the era of open wicked problems is

profoundly enhanced to its traditional definition: it is not only for students, not only in classrooms and labs, and not only for gaining knowledge and skills to fit in the professionalized life. Everyone has the potential to learn, everywhere (particularly with the support of digital tools), to be involved in their social lives weaved by the open wicked problems and at the same time to develop themselves for the complex reality and the uncertain future.

The vertical model of learning is then challenged. Traditionally, students learn from professors, apprentices learn from masters, and the unlearned learns from the learned. But in the new model, everyone learns from a variety of contents and from a variety sources, instead just following the traditional vertical development trajectory. Horizontal peer learning happens among anyone who knows something. Can a professor learn from a student? Sure, when the student knows more design knowledge than an engineering professor, or more about twitter for publicity. Boundary crossing collaboration becomes a common and significant approach to fulfil the horizontal learning in complementary to the traditional vertical development following an individual or competitive model.

Multiple formats of horizontal learning emerge. Workshops, competitions, hackathons, and citizen science initiatives are becoming more and more important opportunities for learning in the emerging culture. At the same time, on-line learning tools largely facilitate digital horizontal learning: e.g. MOOC, webinar, open source hardware and software, open science toolkits, etc. All of these efforts have challenged the traditional situations of learning where students stay in classrooms or labs and follow the instructions of a teacher or a professor. Learning can happen in many situations where communication and creation of knowledge is facilitated, either by off-line activities or on-line tools.

The open wicked problems also accelerate the change of professionalized world. Many jobs are emerging fast: the job of youtuber did not really exist a few years ago, but now it is a choice for many young people, which even pushes traditional TV media to follow the trend. Learning as preparation for professionalism is challenged. Many encounter the problem that what they learn in formal learning does not contribute much to their later professional life. One of the reasons is that the fast-changing problems of our time require agile and adaptive learners rather than well trained workers. Learning should meet the need of the changing job market, which is ultimately attributed to the need of solving open wicked problems. Graduation is not the final stop of learning. Learners are required to keep learning in work and in life so that the complex problems we face will be resolved with agile and adaptive wisdom. Instead of profession-oriented learning, the new problems urge a scalable life-

long learning so that we can keep our pace of innovating and knowledge creating to solving them.

To conclude, the open wicked problems have profoundly challenged the way we learn in multiple aspects:

- The shift from classical problem to wicked problem calls for problem/project-based learning.
- The demand for holistic knowledge in solving wicked problems calls for boundary-crossing and interdisciplinary learning
- The “openness” of the open wicked problems calls for a horizontal and collaborative life-long learning for everyone

Learning in the era of open wicked problems is extended: from solving classical problems to resolving wicked problems, from a separation and specialization paradigm to a holistic and problem based paradigm, from individual based to collaboration based, from vertical and unidirectional to horizontal and bidirectional, from profession learning oriented to agile and adaptive learning oriented, from studentship learning to life-long learning.

New models of learning are crucial in our time for solving open wicked problems. The changes we mention are now raising increasing attention. For example interdisciplinarity is growing internationally and is receiving increasing grant (Rylance, 2015)(Frodeman et al., 2017). But the implementation is however difficult and calls for in-depth study(MacLeod, 2018)(Graff, 2015). The new model of learning is a wicked problem, there is no single knowledge for explaining it, nor there is a fixed method for studying it, or a final solution that we all hail to. Studying the new learning for open wicked problems is an emerging and urging task, at the crossroad of different recent learning approaches, e.g. project-based learning, interdisciplinary learning, and collaborative learning.

3. The Emerging New Learning Model: CoLAB (Collaborative Learning Across Boundaries for Open Wicked Problems)

Confronting the challenges of open wicked problems, the society of all levels are motivated to innovate the teaching and learning models: for policy makers, new learning models are seen as essential engines for national competitive power; at the industrial level, the job market anticipates a growing demand for learners who can agilely adapt the fast change of jobs; in education, educators and practitioners look for new ways to cultivate the “21st century competencies”.

During the past few years, the author of this thesis has been an active practitioner in the educational innovation in China and Europe. There is an increasing need for educational reform to meet the challenges of open wicked problems, especially in China, where the society is undergoing fast changes at all levels.

In China, the motivation to innovate learning and education is high for policy makers. After several decades’ fast growth, China is now the second biggest economy. But since the 2010s, China’s economic growth rate is witnessing a decline trend. The Chinese government believes the ultimate problem is in the industry structure, and therefore promotes the “supply-side reform” to replace the low-added-value, high-consumption and high-pollution industry with the more innovative, green and high-tech industry. Innovative and creative talents are therefore considered a key national competitive power to reach this goal. This policy has led to the reform of its education system, especially its Gaokao (National College Entrance Examination) policy since 2014. The new Gaokao policy requires that the K12 education should pay more attention to the “comprehensive practice competencies” which include collaboration, innovation, complex problem-solving, and digital literacy etc.

Besides the political drive, the industry and job market also motivate the reform of learning and education. In 2019, Jack Ma, the founder of Alibaba, in a conversation with Steve Forbes, said that he believed that art, music and team work is more important than math and physics, given the background that machine and AI will replace human in jobs that are based on memorizing and calculating. Therefore, human will work on more complex tasks, based on skills that are more complex and “human” – as in art, music and teamwork. The change of the job market has directly influenced the change of education, e.g. the one of the education reforms in China has specifically required a focus on the vocational preparation and planning. The traditional learning system tends to isolate the textbook knowledge with the real world need in the

job market. With the fast change of job market and the relatively slow change of textbook knowledge, this tradition has created a giant gap between education and vocation nowadays.

How does educational system react to these political and economic motivations? There are many new learning initiatives emerging. The following sections introduce the new learning initiatives that we observed and co-organized during the first years of our research. We use these new learning initiatives to illustrate the new learning models in the era of open wicked problems.

Examples of “Co-lab” Like Activities

One of the new learning initiatives are the “Co-lab” workshops (please note here the “Co-lab” in small letters is NOT the same as the concept of “CoLAB” in the thesis title, we will discuss the difference in the following section of this chapter).

The Co-lab workshops are a series of workshops during 2015-2017. “Co-lab” is the Japanese word for collaboration and at the same time short for “co-laboratory”. The workshops are experimental workshops that aggregated designers and biologists to work on an interdisciplinary project. There are different sessions in the workshops: normally, there is a design session where the scientists can learn the designerly approach from the designers, and a science session where designers can learn and practice science, and finally an interdisciplinary session where they group together to work on an interdisciplinary project of their choice. The workshops became quite popular in some design and biology communities in Europe and China and continued to host different editions in universities and institutes like UCL, CRI, Cambridge, EPFL, Tsinghua etc.

Co-lab workshops



Fig. 0.1 The format and different editions of Co-lab workshops

The most special thing about Co-lab workshops is that it was started entirely by students but succeeded in making considerable impact. Co-lab workshops were co-founded by three young students, as shown in the follow figure (Fig. 0.2). They are a design bachelor student from Japan, a bioengineering and education master student from Spain and me, a 27 Ph.D. candidate from physics and design who just came from China to Paris. At the beginning, the student group did not have any money or human resources. But they were passionate in promoting in-depth communication between designers and biologists. They discussed the idea of starting a collaborative workshop with different people and received many useful advice, which helped them build their mentor team and raise funding from various grants. The student-led initiative soon became popular in the innovative design and biology communities, e.g. synthetic biology community. With the help from these communities, this new format of learning entered universities in Europe and China and evolved into many editions covering more and more topics.

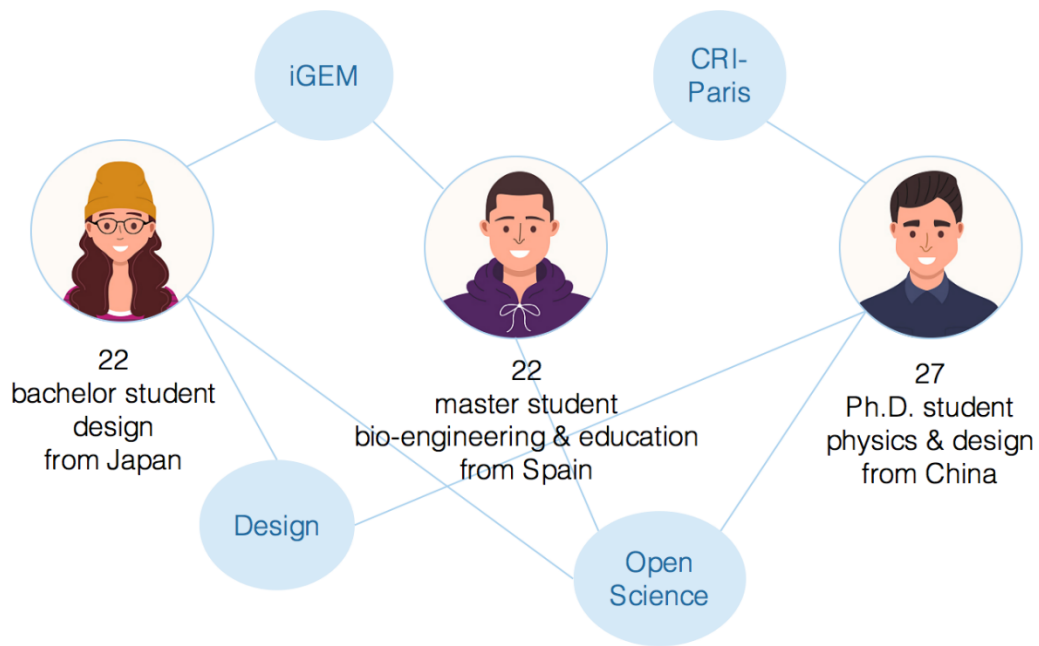


Fig. 0.2 The three co-founders of Co-lab workshops

The author of this research is both one of the co-founders of “Co-lab” and at the same time a participant-observer who studies the learning process in Co-lab. In chapter 8, when we analyze Co-lab workshops, we will make a more in-depth ethnography of Co-lab workshops: their format, philosophy, organizers and participants. Please refer to the according contents in Chapters 8 for more detail of Co-lab workshops.

But the “Co-lab workshops” were not the only one learning initiative that we encounter and study. During the past years when we conduct our research, there are many similar learning initiatives emerging. As shown in the follow figure (Fig. 0.3), we (co)organized, participated, and observed many different learning initiatives. Although they have differences in topic, participant, format, they do have underlying connections: e.g. core organizers of Co-lab started SDGo, a high school competition focused on UN’s sustainable development goals. Although the basic format and participants are different, the organizers inherit their spirit and approach in the SDGo initiative.

More “Co-lab” s

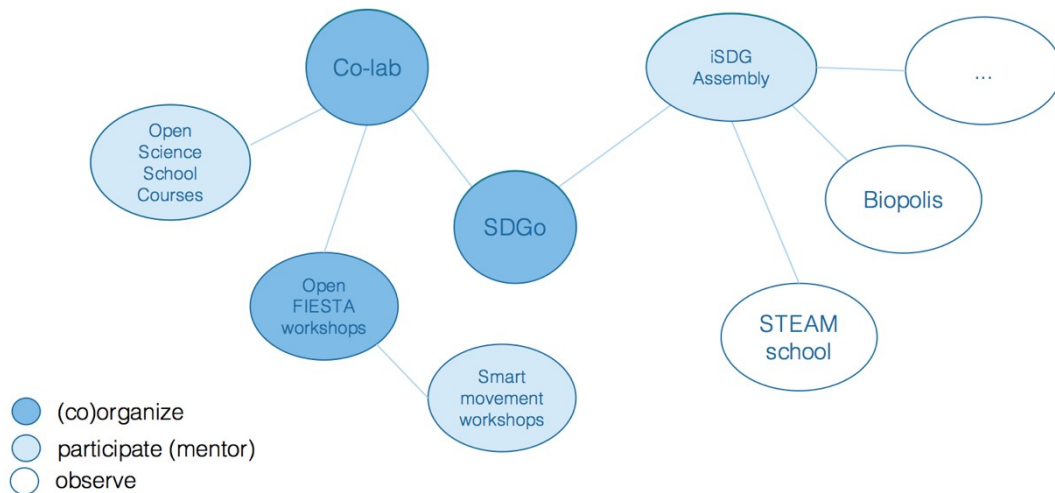


Fig. 0.3 The “Co-lab” like activities

In the following, we will illustrate some of these learning activities related to the United Nations’ Sustainable Development Goals, and particularly SDGo to showcase what these “Co-lab” like activities are like.

In 2015, the United Nations announced the Sustainable Development Goals (SDGs) that listed 17 main goals to achieve global sustainability before 2030. The goals are: No Poverty, Zero Hunger, Good Health and Well-being, Quality Education, Gender Equality, Clean Water and Sanitation, Affordable and Clean Energy, Decent Work and Economic Growth, Industry Innovation and Infrastructure, Reduced Inequalities, Sustainable Cities and Communities, Responsible Consumption and Production, Climate Action, Life Below Water, Life on Land, Peace Justice and Strong Institutions, and Partnerships for the Goals. The 17 goals set up a framework under which everyone can contribute to the global sustainable development. The SDGs problems are typical open wicked problems – they are ill-defined, complex to solve, largely entangled with different factors, and accessible to everyone.

Practitioners, educators and learners started to target SDGs problems in their learning activities following the announcement of the SDGs. The open-wicked-problem nature of the SDGs promotes the educators and learners to adopt new learning models that are more problem-based, more collaborative, more horizontal, more agile and more adaptive. In the summer of 2017, over 100 international students and teachers from across the globe aggregated in the campus of Tsinghua University of Shenzhen, China for a global gathering called the “iSDG Assembly”. The gathering invited 5 learning initiatives originated from different universities and institutes, namely the Biopolis Summer School, the CRI-Open FIESTA SDG workshop series, the CHIC program, the Tsinghua-Geneva Initiative (TGI) Summer School, and the

SDGo Competition. The different initiatives, although with different topics and pedagogical techniques, share common features of a new model of learning facing the challenge of the Open Wicked Problems.

- The Biopolis Summer School

The Biopolis Summer School, with the slogan of “biology and social innovation” is a summer school organized by Harvard, in collaboration with the Center for Research and Interdisciplinarity (CRI), SciencesPo, and the City of Paris.⁴ The Biopolis summer school was started by Robert Lue and Alian Viel of Harvard in the summer of 2015. The overall aim for this summer school is to apply biological principles at all levels (e.g. evolutionary biology principles) to solving urban challenges in Paris. In the 2017 Biopolis summer school, the target urban challenges have a specific focus on SDGs 3, 4 and 11, which are public health quality education and sustainable cities. In two months, students from Harvard, CRI and SciencesPo formed an interdisciplinary group to identify a local problem by engaging in the urban life of Paris, and propose an actionable project to innovate towards a more sustainable future. The final projects are presented with videos as prototypes, which integrate the biological principles, the real-world SDG problems and the solution. For example, the team PICKMEUP designed a vending machine that sells food at discounted price in relation to the food freshness in order to prevent food waste. They were inspired by the symbiotic relationship between plants and nitrogen-fixing bacteria.

- The CRI-Open FIESTA SDG Workshop Series

The CRI-Open FIESTA SDG Workshop Series are a series of workshops between the Center for Research and Interdisciplinarity (CRI) and Open FIESTA of Tsinghua University in Shenzhen. From the 2015, the CRI students and professors have been visiting Shenzhen to hold a week-long workshop targeted at solving SDGs problems with digital technology. The Open FIESTA students who joined the workshops have a divergent background of engineering, science and design. They needed to target a problem in the beginning one or two days of the week and then work on a prototype for presenting in a public maker space at the end. In 2017, the students first visited the hardware market in Shenzhen for identifying a local SDG problem and then applied the digital technology and making their prototype for solving the problem. For example, one of the groups discovered many kids in the hardware market were left unattended as their parents were busy with their business, therefore they designed a special maker kit for them to play and learn at the same time.

- The CHIC (China Hardware Innovation Camp) program

⁴ See more details of Biopolis at: <https://www.thebiopolis.com/home>

The CHIC program is a year-long program curated by the university of EPFL. It is a program to solve real world problem by designing and making connected devices. Students joined their interdisciplinary team of engineering, business and design, at the end of October in Switzerland, and identified the problem before they kick-started the prototyping phase in the spring. They spent half year prototyping the device before they arrive in the world's hardware capital - Shenzhen in July and utilized the hardware to finalize their design and prototype. In 2017, the CHIC program focused on various SDG problems from SDG 6 Clean Water and sanitation to SDG 11 sustainable cities. In one of their project Liveloo, the students made a low-price connected device for monitoring water level⁵.

- The TGI (Tsinghua Geneva Initiative) SDG summer school

The Tsinghua Geneva Initiative (TGI) is a two-month summer school, where the students from all over the world join a Geneva-Beijing-Shenzhen journey for solving SDG problems⁶. In 2017, the students teamed up in Geneva where they visited different agencies of the United Nations and other international Organizations, who gave important problems of SDGs that they are currently working on. The students develop their concept and design a prototype for about a month before they went to China for the final two weeks for intercultural communicating and testing and finalize the prototype in Shenzhen with the hardware they need.

- The SDGo Competition

The SDGo competition is a Beijing high school competition that lasts for 2 months. In 2017, the SDGo competition focused on the SDG 6 water and sanitation and SDG 12 Responsible production and consumption. In the competition, the high schoolers teamed up to join a three-phase journey. In the first phase, the students will need to identify a problem with field research and design thinking tools. They are asked to get in-depth understanding of the context of the SDG problem by field observation and interviews. In the second phase, the students will need to look for science and technology knowledge that is potentially useful in solving the problem with the help of some undergraduate and graduate students. In the final phase, the team will need to incorporate their field understanding and science and technology knowledge and make a prototype to solve the problem.

The SDGo competition was initiated by Beijing Normal University (BNU), which then hosted an educational grant for innovations in schools. The organizing team of SDGo competition was a student club based in the CRI (Center for Research and Interdisciplinarity)-Paris, who regularly hosted a

⁵ <https://chi.camp/projects/liveloo/>

⁶ See more details of GTI SDG summer school at : <http://gt-initiative.org/education-programs/summer-school/summer-school-2017/>

series of interdisciplinary weekend workshops between design and biology. The core organizers are a design bachelor student, a biology master student and a Ph.D. student (also the author of this thesis) who works at the interface between design and science. The workshop normally contains three parts: 1. A design section to identify the wicked problem 2. A science workshop/practicum to learn the scientific knowledge and skill 3. A project making / prototyping section to finalize an interdisciplinary project for the problem. The new model successfully integrated undergraduate, graduate and even high school students from different backgrounds, e.g. from science, art, business and design to learn together and work on interdisciplinary projects. The workshop repeated 10 editions in different universities in Europe and China⁷.

During their workshop in China, the manager of the BNU school innovation grant met the team and saw the new model of learning which she believed was the innovation she was looking for. After several rounds of communication, they decided to start a 2-month student competition with the new model, because, as advised by BNU, it is the best way to introduce an unfamiliar form to the school education system in China. As the CRI was promoting education around the topic of SDGs, the competition was finally named SDGo, which meant SDG + Go: to take actions towards solving SDG problems. In term of pedagogy, the organizing team soon adapted their successful three parts into three phases for the high school competition, which are the Grey Phase for identifying the problem: the Yellow Phase for analyzing the problem and the Red Phase for solving the problem. The high schoolers need to make a group of 5-6 people in solving the problem they identify. The following content table gave details of the guidebook that explains the three phases.

⁷ See PART V for more detailed introduction of this workshop series

About SDGo Initiative	3
About SDGs (Sustainable Development Goals)	3
About SDGo	3
Content and Methodology	5
PHASE 1 - GREY PHASE	5
Introduction	5
Launch Workshop: Find a focus and plan your fieldwork	6
Activity 1: Narrative making inspired by daily life (60 mins)	6
Activity 2: Team Building (60 minutes)	8
Activity 3: Critical looking at sustainability (Identifying people and locations to conduct your fieldwork)	9
Toolkit: Critical Looking at Sustainability	9
Hand-in	16
Week 1: Implement the field study	16
Activity 1 - Fieldwork planning and implementation	17
Toolkit: Fieldwork methods: observation, experience and interview	18
Week 1 Hand-in: field-work methodology	24
Week 2: Improve and wrap up you study, analyse and report	25
Activity 1: Reflect and Improve your study, repeat it if necessary	25
Activity 2: Analyse your data, redefine initial topics and questions	25
Week 2 Hand-in : Grey phase report	27
PHASE 2 - YELLOW PHASE	28
Introduction	28
Launch Workshop: Guesstimation: Solving the World's Problems on the Back of a Napkin 在餐巾纸上解决世界问题	29
Week 3: Approach and break down the problem / question	34
Activity 1: Break down the center topic into specific questions.	34
Activity 2: Identify the roles	34
Hand-in:	36
Week 4: Build knowledge map from different disciplines	37
Activity 1: Play with the knowledge cards:	37
Activity 2: Build knowledge map from different disciplines	37
Hand-in:	39
Week 5: Interdisciplinary debate: A Final Converge!	40
Activity 1: Debate !	40
Activity 2: Converge !	40
Hand-in: Yellow Phase Report	41
PHASE 3 - RED PHASE	43
Introduction	43
Week 6 - 7: Thinking through making	45
Activity 1: 'Make' your communication (Week 6)	45
Hand-in:	50
Activity 2: Make, Make, Make! (Week 7)	52
Hand-in	52
Week 8: Finalize and present it in the public	53
Activity 1: Release in the public + Making a final presentation + report	53
Hand-in: Red Phase Report	54
Final Workshop (2 days workshop): Learning how to present better - an interaction based programme	54

Table 0.1 Content of SDGo guidebook in three phases

The Grey Phase includes an on-site launch workshop as a kick-starter for the competition and two weeks of fieldwork to identify the SDG problem. The launch workshop aims to equip students with the ability to critically view sustainability within their social, economic and cultural context, and plan their own field study in this context. During the first week, students will conduct

their own field study based on the plan designed during the workshop and the guidance from the guidebook. The second week is the time for the students to integrate their first fieldwork results, improve and repeat the study if necessary and finally redefine their initial questions with their analysis of the data. The Grey Phase integrated ethnographic method and design thinking tools which the organizers often use in their design workshops.

The Yellow Phase is a three-week section where the students need to learn interdisciplinary knowledge that is potentially useful for the problem. In week 3, the students re-examine their SDG topic and questions brought from the Grey Phase, and identify how their questions can relate to knowledge and references from different disciplines, and divide themselves into several small groups inside the team to work from different disciplines. The next week, Students learn and exercise academic skills to research the existing knowledge and state-of-the-art solutions to the problem and try to build an interdisciplinary knowledge map from the reference they found. In week 6, students need to integrate the different knowledge in a debate and learn how to really reach meaningful results in an interdisciplinary setting.

The Red Phase is the final stage for the students to give their ideas a chance. During the week 7 and 8 they utilize the discoveries they made in Phase Grey and Yellow to create a prototype of their concepts. The focus is not about thinking and analyzing but making and testing. During the final week of the competition, students are expected to focus on the presentation and the outreach & social media aspect of their project. Students will be introduced to communication skills and methodologies to help them create a presentation and report.

As the organizing team is mostly based in Paris, they use on-line tools for mentoring the high school students. The student team needs to weekly hand in a working sheet to summarize their progress in the week and get feedback from three advisors, mostly graduate students and undergraduate students from different background who read their report every week.

Week 3 Hand-in:

Your topic and questions :
Break down the topic and questions into small problems that relate to different disciplines put questions/ problems and disciplines below : (e.g. how to use biodegradable material for disposable cups - biology, material science ; how to present people to waste food when they order online - behavior economics, psychology)
Group 1 Group members and roles: Questions/ problems and disciplines :
Group 2 Group members and roles: Questions/ problems and disciplines :
Group 3 Group members and roles: Questions/ problems and disciplines :
Why do you choose these questions, and how are they organised to answer the core question of your topic ?

Table 0.2 Hand-in template for the student to sum up their progress weekly

The above table (Table 0.2) is the third week hand-in template for the students to summarize their weekly progress. In the template, the student team is asked to break into 3 sub-groups and search for knowledge that is potentially useful for their problem. The following sheet is the answer of the second sub-group of the team “Heterogenius” who focused on the over packaging problem of the growing delivery business in China. And the second sub-group chose to look at the problem from the material science perspective and studied the structure of corrugated paper in the aim of finding new solutions that makes cardboard recycling more friendly (Table 0.3).

Group 2

Group members and roles: Eric&Peter

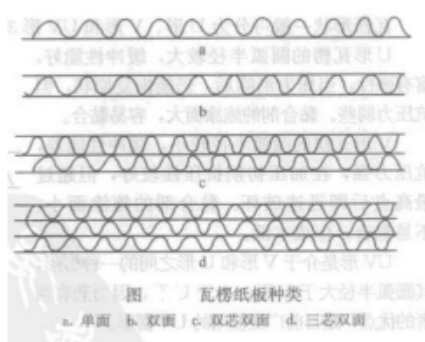
Questions/ problems and disciplines:

2. Material Science: What modification will protect the completeness of boxes and solve the problems?

The card board are made up with several piece of Corrugated paper (or folded from a big one). In order to make the box suitable for recycling, we can enhance the box in several aspects.

The first problem is that the company will not recycle the box with other brand printed on it, so the best way to solve this problem is to link several company and make them a combination, the member in this combination will use the same cardboard box with no single name of the company on it. Thus, this will be really helpful for recycling. What's more, we should build the box with the standard shape with scale to 1-12, this will also help with the standardize of the card board box.

The most important part that I'm going to improve is the quality of the boxes, this is mainly depending on the structure of the corrugated paper. The thickness of the corrugated paper is categorized as 3 layers/ 5 layers/ 7layers. The three-layer paper are consisting of two face paper and one layer of corrugate, the five-layer paper are consisting of three face paper and two layers of corrugate. Etc.



The outside packing mainly uses four methods to arrange corrugate layer, there are: A/B/C.

The A corrugate layer has less corrugate in unit length, but its corrugate is the highest, it has a big buffer force exert on it when it drops, and its suitable to pack some thing that is light. The B corrugate layer has most corrugate in unit length, by contrast, it has least height of corrugate, so its suitable for pack heavy things. The C corrugate layer's index is between A and B.



Also there are three different ways to make

the

Table 0.3 Week 3 Hand-in answer of the second sub-group of the team "Heterogenius": from the material science perspective

After receiving the hand-in, three advisors gave their answers following an advice template. The template is deliberately designed for giving open and constructive advices. The following advice sheet is the Week 3 advice given to "Heterogenius" from one of the advisors (Table 0.4).

Advice Template

1. What do you like the most about this team's progress since last week, and why? I really enjoy the amount of effort you put into research. Seems like you know your subject really well ! Congratulations! It seems like you have really managed to focus on a good subject!
1. ONE piece of knowledge (e.g. information, an existing project, reference, a perspective, a method or a theory, etc.) that you would provide or recommend to the students (describe and/or provide reference link), and how might it help improve their project? Try to look at the cardboard standards and why they are built like they are. Sometimes, resistance to stress is not the only reason why the cardboard is like that, but material optimization is key as well. By knowing why the cardboard and tape are used like they are you may have a better grasp of your subject.
1. What keywords would you suggest the team use when searching for other resources of knowledge (e.g. information, an existing project, reference, a perspective, a method and a theory, etc.)? (provide and ONLY provide 2 - 3 keywords) <u>__industrial standard__ , __amazon__ , __delivery good practices__</u>
1. Answers to the student team's question proposed last week: Interdisciplinary: What do you think is the problem involved in the current reusing system? I think the biggest problem is that the customers are not used to recycling. You might explore why, and what would be good incentives to get them into a habit of reusing boxes. Material Science: What modification will protect the completeness of boxes and solve the problems? For this question, you have the advantage of being able to test it yourselves. If you have access to a 3D printer, you can model and print some models and test their resistance! Management: How does JD cardboard reusing system function? It seems like you have become experts about that question, well done! You might want to see if any other companies do the same and get inspired from them as well.
1. How knowledgeable are you of the field of the question you have answered in question 4 :
Barely know 1 2 3 4 5 Very knowledgeable

Table 0.4 Advice Template and Week 3 advice from one of the advisors to “Heterogenius”

The advisors have a divergent background from business, design to engineering and science. The high school students are responsible to integrate different advices for their project.

Besides the online communication, the students also make at least one physical gathering every week, when they discuss their past week progress, the feedback from the advisors, and their next week plans. An undergraduate tutor from BNU joins the gathering to facilitate them when they need. The tutors from BNU are all trained by the core organizers to make sure they align with general flow of competition. Some of the high-quality advisors also call in when the student group meet every week. The different levels of mentoring make sure the student group gets an open and divergent supports.

The SDG problems students chose are open wicked problems closely related to their life. And their solutions also directly contributed to solving the problems. For example, the team of “Wen Jiajun” found out most used textbooks and practicing books are just thrown away, but many of them are quite new and ready for reuse. They invented a loose-leaf notebook so that the textbook and practicing books can be reused. They not only invented the product as an idea, but prototyped it and tried it in their school. They went to their affiliated junior high school to promote their products and started a campaign of the loose-leaf concept. As a result, they influenced hundreds of students in their school and the loose-leaf paper sales tripled in the store near their school. The learning activity did have a real-world impact upon solving/resolving the open wicked problem.

Learning towards solving open wicked problems is not easy. Very often the students find themselves in the situation of failing and iterating. The team “Reopt” explained the feeling of their learning journey: “At first, we believe we are going to change the world, at least for the problem we tackle, but soon we find out there are giant walls stopping us, and each time we try another direction, we find many more other walls. In the end, we finally understand that we are not breaking the walls but looking for slight gaps between the walls and see if we can grow our project there to change the status quo.” The giant walls they referred to are the wicked problems and the entangled factors that contribute to the problem. The team started their project from the observation that high school students often change eyeglasses as they grow up, but the used glasses are never recycled. They wanted to promote the recycling of eyeglasses in the high school community. They first learnt about the materials of eyeglasses and found out neither the recycling of the frame or the glass is economic. They tried another direction of recycling by collecting and donating used glasses, but then found out the model has a major flaw that the donated glasses might not fit another person, which might even do harm to their eyes. Finally, they found out there are a few NGOs in China raising money to buy glasses for the kids living in the remote countryside. The “Reopt” then proposed to donate campaign in their school and donated the eyeglass frames to the NGOs. This donation would considerably reduce the

money needed for buying new glasses, so that the NGOs could help more kids with the money they have. In their donation activity, they also encouraged their student peers to write to the countryside kids. In this way the donated frame became a bridge to connect the two remote communities.

Abduction: From the Small Co-lab to the Big CoLAB

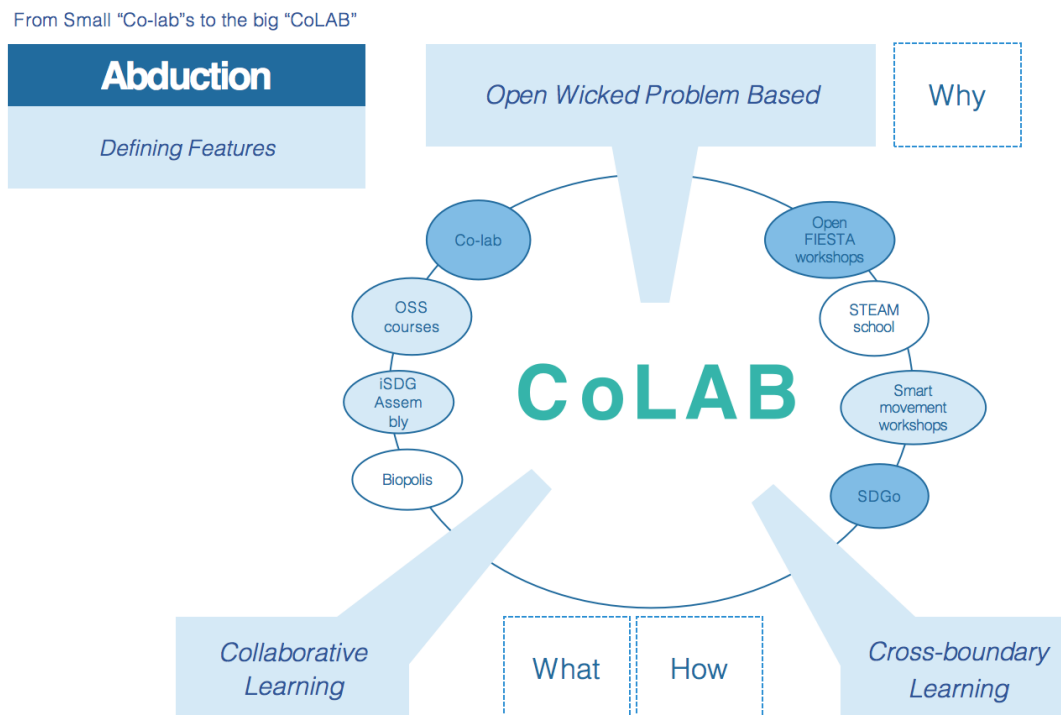


Fig. 0.4 The three defining features of the new model of learning - CoLAB

In the previous section, we illustrate some of the “Co-lab” like activities. Although they are mostly different in formats, they share similarities and connections. In this section, we will follow an abductive logic in understanding the different “Co-lab” like activities by abducting the most significant features of the Co-lab like activities, which give rise to the concept of the big CoLAB learning.

● Open-Wicked-Problem Based Learning

The objective and process of the new learning model are evidently different from the traditional model of learning, especially from the instruction-based learning. The key distinction is that the new model of learning has an open-wicked-problem based learning objective and process.

The traditional objective of learning is knowledge based and defined by the instructor. For example, in math classes, the teacher sets up the goal for

understanding certain approaches for solving a type of equations. In this way the learning objective is relatively clear and predefined. But in the new learning model, the goal only becomes clear and substantial as the learning unfolds. The learners and mentors do not know what exact knowledge they will need beforehand, therefore it is not possible to define the objective in terms of knowledge in advance. As the learners get more involved in solving the open wicked problems, they start to define what they will need to learn in order to solve the problem. The mentor's role is to facilitate this process and help them better frame their learning objectives. As the open wicked problems are entangled with many aspects of knowledge, the learning objectives always change and iterate on various conditions. In the case of "Heterogenius" team of SDGo competition, one of their direction in Week 3 is to look for material science knowledge of the corrugated paper. But as they further their research, they find out the habit of recycling is crucial in their solution model. The open wicked problem concerns many aspects of knowledge during the learning.

The learning process of the new learning model is also open-wicked-problem based. The learning process is inseparable from the process of solving the problem. In traditional model of learning, the learning process is relatively isolated and independent to other activities. But in the new model of learning, learning happens at the same time as learners inquire, communicate, debate, inspire, prototype, validate, and present. All these activities towards solving wicked problems are at the same time learning activities. The team "Reopt" of the SDGo competition discovered that their biggest chance of recycling eyeglasses is through donating eyeglass frames to NGOs who give eyeglasses to the countryside kids. The team had to communicate to the NGOs and persuade them the value of this project. But how should they do that? They had never done anything like that before, and they had to learn how to communicate to a NGO, to understand their need and to persuade them. Therefore, they consult people they know who have alike experience and learn through the whole process. Another team of "Homerun" wanted to solve the problem of food waste in restaurants and they had an idea to actually open a temporary restaurant in their high school to observe and test their solutions. In order to open the temporary restaurant, they have to persuade the school managers, apply for a funding, obtain food security qualifications from their supplier, write to the parent committee, at the same time to observe and analyze. These activities help them to better understand both the providers and the customs. None of these activities are traditional learning activities, yet they constitute the necessary process of solving the open-wicked-problems. And the learning accompanies the process of identifying, analyzing, and solving the problems.

- **Collaborative Learning**

Collaboration is one of the key features of the new learning model. In the above examples, all of the SDG learning initiatives adopt a collaborative learning format. The students are grouped into 2-6 people and compete their learning in the unit of groups. In the beginning of their learning, learners group based on different strategies, e.g. common interests, heterogenous skillset, etc. As the learning continues, learners work together in identifying, analyzing and solving the open wicked problems. In the new model of learning, the “openness” of the problem ensures that everyone can contribute to the problem. Therefore, in most cases, there is no “expert” who should dominate the group or a completely “outsider” who knows nothing to contribute. Collaboration naturally happen in this group dynamic where the leaners collectively define and construct their project in solving the open-wicked-problems.

Adopting the collaborative learning format is based on the following considerations: 1. In real world scenarios, most work to solve open wicked problems are done through collaboration in the working environment. Since the new model of learning has the authentic object of solving open-wicked problems. It does not present an essential difference. 2. As the problems are often complex, it is useful to promote collaboration for a holistic perspective. As open wicked problems challenge the separation and specialization of knowledge, individual model will likely fail to provide a comprehensive perspective.

With the pervasive use of digital technology, the collaboration now can be both on-line and off-line. Many on-line technologies are being used to facilitate collaborative learning in the new model of learning. For example, the SDGo competition adopted the remote mentoring as most their mentors were in Europe while the learners were in China. Also, in the GTI summer school, the participants needed to attend a completely on-line session called open 17, before the two month summer school. The open 17 session used MOOC, on-line tutoring, and on-line discussion as the major forms to collaborate. Off-line collaboration is still the major format of the collaboration, but we anticipate that the on-line collaboration will be more and more important in the future as the need for remote communication, learning and collaboration increases.

The collaboration in the new model of learning is different from the “Division of labor” in professionalism. The role of each learner is not predefined. As the problem and the solution is unknown to the learners before learning, they will need to collaboratively work on identifying the problem and co-constructing the project to solve the problem. This process will require everyone to contribute their intelligence, which differs from the “Division of Labor” model. Division of labor is only limitedly used in the later stage of the project when

everyone has agreed on the problem and the project hence moved to the realization stage.

● **Boundary-Crossing Learning**

The new model of learning features boundary-cross learning. The collaboration in the new model of learning is more heterogeneous than homogeneous. Learners learn through boundary-crossing communication in their group – they learn from knowledge in another discipline or other communities. In Biopolis, the Harvard and CRI students were more familiar with biology while the SciencesPo students more familiar with social and political sciences. Also, as the team will need to solve a problem in Paris, the Harvard students also learn from local students and communities about life in Paris. In GTI summer school, the students were first grouped based on different skillset so that they can complement each other when there is a need. Then the students went to UN and other organizations, to local and to Shenzhen where they can learn from many other people and organizations about what the problems are and how to implement their solution. In the SDGo competition, although the high school students do not have majors, they present different capacities in different areas: e.g. some are better at sciences while some are better at communicating and emphasizing, etc. The design of the SDGo competition also required the learners to learn from crossing the boundaries – e.g. in Week 3 and 4 they needed to break the team into 3 sub-group to look for potentially useful knowledge in different areas and in Week 5 they needed to integrate them to achieve a holistic perspective.

The Boundary-crossing learning challenges the vertical model of learning. Traditionally the learning is the preparation for the solving the problem, and one can only start to solve the problem once they become a master in the vertical silo of knowledge. In the new model of learning, the situations are different. Learners and practitioner are constantly conducting peer learning and learn from crossing the boundaries of their past knowledge frame and experience. The horizontal model of learning is the norm for the new learning model. In the horizontal learning model, transgressing and expanding is the source of learning and constructing knowledge. Learners do not focus on how to progressively sharpen knowledge inside a vertical area of knowledge, either in a discipline or in a community of practice, but focus on integrate different knowledge and knowledge frame towards pragmatically useful knowledge and experience for the open wicked problems. This boundary-crossing learning feature means that there need not to be a rigid frame of how knowledge should be constructed so that everyone can follow in a vertical way. Instead, everyone's background, discipline and experience should be useful in a fluid way in the learning towards solving the problems. The

direction of learning is also blurred as we can observe learning happens between students and professors in both directions.

There are two major forms of boundary-crossing learning in the new model of learning. The first is interdisciplinary learning. Disciplines are still the major form of boundaries of learning scenarios. We are quite used to refer to disciplinary knowledge when we learn. In solving open-wicked-problems, disciplinary knowledge is also indispensable. However, no single disciplinary knowledge is enough for open wicked problems. We need to cross the boundary of existing discipline and integrate useful knowledge. The second boundary-crossing learning is crossing communities of practices. The open wicked problems, especially the “openness” element, requires the learning to incorporate experience across different communities of practice and experience. In SDGo competition, the high schoolers need to cross the boundary and learn from the community of street cleaning workers in order to better understand the problem.

We conclude three indispensable features of the new model of learning that emerges from facing the challenges of the open wicked problems (see Fig 0.4). Each of the three features are not entirely new. For example, the problem-based learning can be originated Dewey and the Project Method in the progressive education wave, and more recently their wide use in the universities for complex task such as surgery in medical schools. Collaborative learning can be dated back to the 70s where teachers started to use cooperative learning skills to promote better student performance. Boundary-crossing learning can be originated to interdisciplinarity and expansive learning. For detailed review of the different learning models separately, please refer to the PART I. LITERATURE REVIEW AND METHODOLOGY.

The three defined features shown above helps us define the new model of learning. We call this emerging learning model “**CoLAB**”, which is short for “**Collaborative Learning Across Boundaries for Open Wicked Problems**”. The learning model of “CoLAB” does not indicate one specific learning approach or pedagogical method, nor does it indicate learning activities with specific and fixed rules or formats. Instead, it is an umbrella name for a group of learning activities that share the same features. It is however difficult to make a clear-cut definition of CoLAB, as the phenomenon of CoLAB is by itself a wicked problem in our nowadays learning.

- **CoLAB is Open-Wicked-Problem-Based Learning**
- **CoLAB is Collaborative Learning**
- **CoLAB is Boundary-crossing Learning**

The three features are interrelated: The key purpose of learning is to solve Open Wicked problems. To achieve that goal, we need learners to collaborate to authentically solve the problems, as in real world, none of these problems can be solved by one person. The collaboration is boundary-crossing so that different background and experience become a source for learning, not a barrier, as boundary-crossing experience and knowledge are crucial in solving open wicked problems. Hereafter in this thesis, we will use **CoLAB** to indicate the new model of learning in solving open wicked problems.

4. Research Motivations, Questions and Key Findings

In this section, we will explain our research motivation and questions for this thesis. Our research motivation for this thesis is to understand the process of CoLAB with a **practice-based understanding** and a **pragmatic purpose**. The practice-based understanding means we do not enter understanding CoLAB with existing theories, instead we enter through close observation of CoLAB practice and through self-observation in practicing CoLAB ourselves. We treasure the insider understanding of the learning process and we develop our understanding by observing and analyzing the subtle moment and their underlying mechanism in the front-line practice. The researcher is both the practitioner who participates and practices, and the research tool for extracting understanding from his practice. The pragmatic purpose means the research is also oriented to solving real world problems, in our case, to facilitating the CoLAB practitioners, particularly those who are unfamiliar with new learning model. We are motivated to create easily usable analytical tools for these practitioners as well as learners.

The reasons for our practice-based and pragmatic motivation are closely associated with the general research background, as we have elaborated in the above sections, which are:

First, the world is embracing growing entanglement and complexity. The “tame” problems that we are used to are evolving into “wicked” problems that are “ill-defined”. Moreover, the development of digital technology has enabled everyone to be actively involved in solving the “wicked problems”. The “open wicked problems” are becoming the more and more significant in our modern life: from climate change to AI ethics, from new entrainment like TikTok to new application of cutting-edge biotechnology.

Second, the pervasive “open wicked problems” challenge our current learning and education system. The traditional science and engineering model is not sufficient in solving the problems. The “wicked” nature of the problems requires a holistic perspective instead of the separation of knowledge. The

“open” nature of the problems result in horizontal and boundary-crossing learning in addition to the traditional vertical model.

Third, to answer the challenge, new learning models are emerging, which is a result of both political motivation for enhancing national competitive power and economic motivation for fitting the fast-changing job market. The new learning models are now entering as part of our official education system, e.g. the different SDG learning initiatives gathered in Shenzhen in 2017. There are three key features of the new model of learning: open-wicked-problem-based, collaborative learning, and boundary-crossing learning.

Under these backgrounds, since the 2015, the author has been an active practitioner of the new trend of learning, as a participant, an organizer, a promoter and a trainer. At the same time, the author is also a researcher trying to better understand the CoLAB phenomenon and improve the practice, which is the original motivation for this thesis. As the practice and research deepens, it has exposed two key issues of CoLAB that further motivates this thesis, especially in its research focus and methods.

Research Motivations

● Research Motivation 1: A Practice-Based Understanding

The CoLAB learning is by itself an open wicked problem, which means it has its own complexity in practice. Therefore, understanding CoLAB will inevitably needs a practice-based perspective for the following reasons:

First, Organizing and implementing CoLAB is an open wicked problem. Although we have explained several key features of CoLAB, there is no definitive formulation of CoLAB learning. CoLAB is ill-defined, presenting various forms, methods, while reaching to divergent participants, organizers, and topics. And the change of the conditions will largely change the problem itself. A good format of CoLAB for one group of participants may not work for another group of participants, the same material or even methods might hardly work with another topic or by other organizers.

Furthermore, there is no definitive final “solution” or “recipe” for CoLAB either. The problem itself develops as we practice it. The entanglement and complexity of the problem makes it difficult to adopt a traditional science approach to “measure” and “optimize” as for a classical “efficacy” problem. Studying CoLAB needs to stay close with the subtle understanding from the practice and embrace its complexity.

The third reason for a practice-based perspective is that CoLAB adopts a learner-centered approach. The learners are the center of the learning activity, which aligns with the “open” property of the “open wicked problem”. With the learners in its center, the CoLAB learning is not understood as an instructional design, but an entangled activity and complex social process where every factor coordinately defines the problem.

As Rittel and Webber (1973) pointed out, understanding the wicked problem is inseparable with solving the problem. The understanding needs to incorporate the solving as part of the problem. At the same time, the solving and practicing is one way to understand the problem. This understanding of CoLAB is the reason for our research focus and method to incorporate with a practice-based perspective.

● **Research Motivation 2: The Pragmatic Purpose**

There exists a growing need of pragmatic guidance for a diversity of practitioners and learners of CoLAB. The CoLAB activities are becoming more and more popular in universities and research centers. As exemplified by the examples of SDG learning initiatives, the new model of learning is supported by universities and research councils as part of the official pedagogy. They spend a lot research funding and teaching resources for these kinds of learning project, which is not at all routine in the traditional university model. The organizers are divergent: there are professors who are interested in the new model of learning, professors that has been working on boundary crossing subjects, research council managers who promote educational innovation, and even learners who feel the need to collaborative and change. The diversity of practitioners and learners requires the pragmatic knowledge on how to implement CoLAB to be easily accessible, especially for those who just shift from traditional educational system or those who haven’t changed their mind but are given the task to establish a CoLAB-like learning initiative. They will need to understand the study of CoLAB without scrutinizing a complicated theoretical background. The gap between the theoretical ground and the practice needs to be filled.

The study of CoLAB oriented to improving the learning experience is in great demand for practitioners. Implementing CoLAB is difficult for two reasons: 1. the open wicked problem people trying to solve with CoLAB is complex and difficult; 2. The CoLAB is by itself an open wicked problem and hence difficult to deal with – it concerns many entangled challenges concerning institutional and cognitive barriers. This pragmatic oriented study should consider the fact that the most majority of CoLAB practitioners does not have a firm background of learning sciences or educational research. Filling the gap between practice and theory requires the study of CoLAB to firstly have an in-depth understanding of the real-world problems of the practitioners and

secondly be presented in a way that the divergent practitioners can easily understand.

The pragmatic purpose of the study of CoLAB also aligns with the personal motivation for this thesis. Before the Ph.D. study, the author was a learner in the CoLAB learning initiative in China. As China's economy develops, the need of solving open wicked problems also increase. The trend has also infiltrated into many universities and research centers in China, where they are asked to design and implement new learning initiative to solve complex problems with collaborative efforts of people from different background. However, many new learning initiatives are facing practical difficulties- they do not know what a CoLAB learning is like, what the key issues are and how to overcome the barriers. During his Ph.D. study in Europe, the author of this thesis has developed his experience in CoLAB organizing and curation through his constant practice with different learners, professors and the CoLAB communities. Therefore, one of the motivation for this thesis is to materialize the experience and understanding of the practice and help the practitioners who have less experience to improve their CoLAB experience.

Research Questions

To conclude, with the above two considerations of CoLAB learning, we hold a practice-based and pragmatic motivation for our research, which are manifested in the following aspects:

- We focus on the complexity of the CoLAB in its practice. We see CoLAB as an wicked problem rather than an “efficacy” problem.
- We ask questions about CoLAB and try to understand them from a practice-based and insider perspective. We focus on the real world challenges of CoLAB practice: for it is firstly the preferred way to study an open wicked problem and secondly it is useful in filling the gap between practitioner and researcher, so that the pragmatic purpose can be fulfilled.
- We use qualitative research methods such as ethnography and grounded theory, which are widely used to tackle complex problems in social and design research. We use these methods to study the complexities of CoLAB rather than to reduce them.
- We regard our research a useful tool to facilitate practitioners and learners who practice CoLAB. We understand most practitioners do not have profound knowledge on learning and educational theories. Therefore, we are motivated to build this pragmatic tool based on our practice-based understanding so that it will best fit the practitioners' use.

With this motivation, we further develop our initial set of research questions as follows:

- **What are the key challenges in CoLAB Practice? How do they influence the process of CoLAB?** When we focus on the practice of CoLAB, we immediately notice that CoLAB learning is not easy. For organizers and learners, there are very often challenges in the process. Trying to understand the challenge becomes our initial motivation for this study: what are the key challenges? What factors influence these challenges? How do these challenges influence the organizers and learners and the process of CoLAB?
- **How do CoLAB practitioners and learners act, react and interact facing these challenges; how do their actions, feelings, and cognitions influence the process of CoLAB?** As the CoLAB is a dynamic process, the challenges are not static. They evolve as the practitioners and learner act and react against them. We want to understand the practitioner and learners' cognitive and interactional behavior in the CoLAB learning process, especially in their key moments, for example, facing difficulties.
- **Who are the CoLAB practitioners and learners? How does the social existence of them influence their CoLAB Process? And How does CoLAB influence them?** The third part of the questions concern the socio-cultural aspect and its relation to the practice. In the era of open wicked problems, learning is no longer an isolated activity in class. Therefore, the socio-cultural aspect of the learners is essential in understanding the CoLAB process. We need to understand who they are, why they come to CoLAB and how CoLAB develops them as a learner.
- **In practice, after better understanding CoLAB, how can practitioner better reflect on the process? how can we improve CoLAB learning to reach our goal to solve the open wicked problems? How can we facilitate practitioners who are new to CoLAB learning?** The final part of the questions indicates the pragmatic purpose of this research. One of the key issues of CoLAB learning is the evaluation of the process. As CoLAB is an open wicked problem, the evaluation is not "tame" either. How can practitioner reflect and evaluate their practice is one of the big question for us? We need to constantly improve CoLAB as every CoLAB is unique. The final purpose of this research is to facilitate the practitioners to better understand and reflect on their practice and to improve them in the future.

We use these questions to set up the initial frame of our inquiry and the purposive sampling in this thesis. But as a qualitative research based on grounded theory (see Chapter. 4 for more detail), these questions will develop and refine themselves as we unfold our research by sampling and analyzing. The purpose of presenting the research motivation and question here in this section do not mean we will mechanically go through these questions through step-by-step logical theorizing or hypothesis testing– we do not follow a logic-deduced method. Instead, the purpose is for the readers to understand what our main focused questions are and why they are important questions to be studied in relation to the general background and motivations of our research. The following illustration (Fig 0.2) presents the relation map of the research background, motivation and questions.

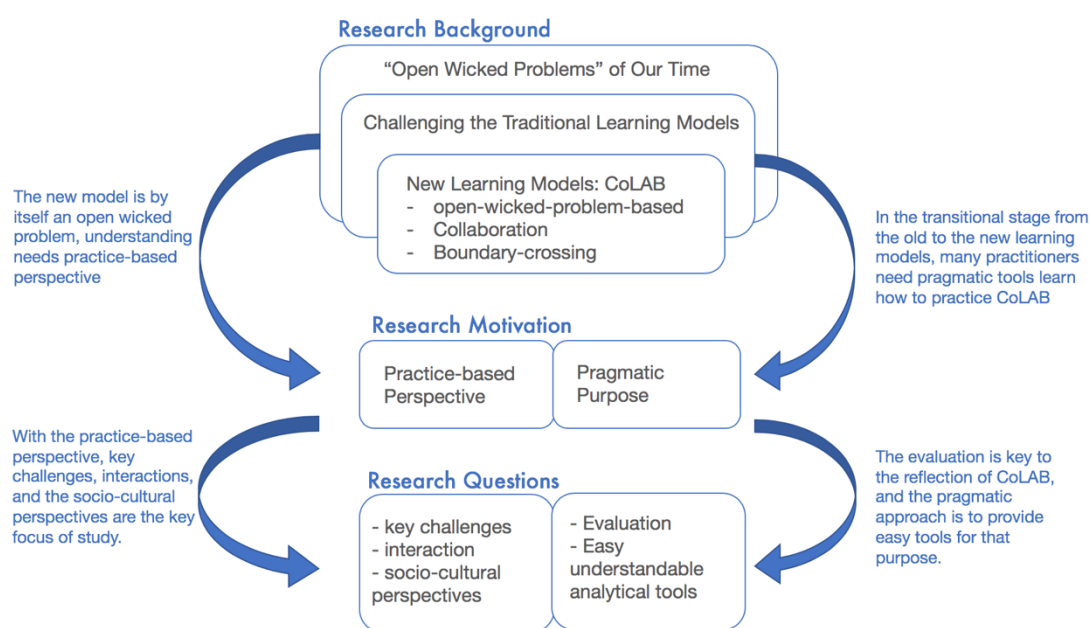


Fig. 0.2 Relation Map of the Research Background, Motivations and Questions.

Key Research Findings: The “Co-Meaningfulness”

In this section, we will give a brief introduction to our key findings, which is the concept of “Co-Meaningfulness” in CoLAB.

As we have explained in the research questions, we start our inquiry from observing and analyzing the key challenges of CoLAB. The “Co-Meaningfulness” emerges as a key concept in our analysis of CoLAB challenge when students find it not enough just communicating on the “project” level, and that they have to communicate and negotiate which part of the project is more “meaningful”. This process is especially salient when the

group faces challenges in the collaboration. The challenge will bring the seemingly divergent opinions and understandings of the “Project” to a more profound level in coordinating different “Meaningfulness” and constructing a “Co-Meaningfulness”, a term we define as the collective, project-related and developing Meaningfulness of the learners. The phenomenon of constructing “Co-Meaningfulness” is discovered as an underlying but significant process in CoLAB learning

“Meaningfulness-Meaningfulness Coherence” (“M-M Coherence”) and “Project-Meaningfulness Intensity” (“P-M Intensity”), as two properties that characterize “Co-meaningfulness” are discovered through comparative analysis in finding out why and how their “Co-meaningfulness” changes over time. The “M-M Coherence” means how coherent the group member’s meaningfulness are related to each other. The “P-M Intensity” means how actively group members engage their meaningfulness into their project - e.g. are they fully engaging or are they compromising their meaningfulness, are they efficiently communicating their meaningfulness so that it will influence the joint project, etc. These two properties are then used as two axes to build up the “Co-Meaningfulness” quadrant map where the CoLAB process can be anchored with a Co-Meaningfulness trajectory. The “Co-Meaningfulness”, the properties of “M-M Coherence” and ‘P-M Intensity’ and the Co-Meaningfulness trajectory are the key results when we take a socio-cognitive perspective in understanding CoLAB.

The discovery of Co-Meaningfulness and the framework of tools to understand CoLAB leads to the inquiry of what exactly “meaningfulness” mean, which can hardly be answered with solely the socio-cognitive perspective. As we continue to analyze a long term CoLAB workshop series, we conclude three key process that are related to the “Meaningfulness” from our coding and analyzing. They are the “Evoking”, “Applying” and “Prioritizing” process. The “Evoking” and “Applying” indicates that the working project “Evokes” the learner’s past related experience and associated social meaning which the learner “Applies” to the current project. The “Prioritizing” means there is not necessarily just one past project and one associated meaning to evoke and apply, and the final meaningfulness is the result of prioritizing the most relevant Project and Meaningfulness, according to the learner’s intrinsic priority and the situational and environmental factors of the learning scenario. “Evoking”, “Applying” and “Prioritizing” connects “Meaningfulness” to the socio-historical and socio-cultural perspective of the CoLAB. When the learners implement multiple evoking, applying and prioritizing, they construct the Co-Meaningfulness. And the Co-Meaningfulness develops as the learners constantly re-evoke, re-apply and adapt their prioritizing.

The “Co-Meaningfulness” is a framework based on our coding and grounded theory with concepts, properties and visualization tools. The main contribution is two-fold: First, it is an easy understandable tool to identify the key challenges in CoLAB during and after CoLAB, which will help practitioners to improve their practice. The Co-Meaningfulness concept can help practitioner, when they meet challenges in CoLAB, to understand the challenge from a more profound perspective at the “Co-Meaningfulness level”. The Co-Meaningfulness trajectory can help practitioner to better locate the key moments and understand the good and bad practices. Second, from a socio-cultural and developmental perspective, The Co-Meaningfulness framework helps the learners and practitioners to understand that each time CoLAB is done, the Project and Co-Meaningfulness is part of the development, as they enters the P/M “library” of the learners, developing the adaptability of their prioritizing. The next time in CoLAB, learners are equipped with more entangled network of experience and meaning as well as more flexible and adaptable ways of prioritizing from which they build the next Co-Meaningfulness - and possibly lead the development of novice CoLAB learners through this new Co-Meaningfulness. Understanding this developmental role of “Co-Meaningfulness” will help us better catalyze the development of individual and the community in CoLAB.

5. Thesis Structure

In this section, we will introduce the structure of this thesis, which provide readers with necessary guidelines for reading.

● INTRODUCTION

We explain the general background, motivation and questions for our research. The general background is three-fold: first, the “open wicked problems” become the pressing problems of our time, as our science and technology problems are inevitably entangled with complex social realities; second, the emerging “open wicked problems” challenge our learning and educational system, and the traditional model based on teaching and vertical learning is not sufficient; third, as policy makers, the industry and educators notice the challenges, new learning models are emerging. The new learning model is open-wicked-problem-based in the form of collaborative and boundary-crossing learning, which we call the CoLAB (Collaborative Learning Across Boundaries). The emergence of the new learning models encourages many learners and practitioners to transit from the traditional model to the new learning model, which calls for a better understanding of the nature of this learning model. As CoLAB is an open wicked problem by itself, we are motivated to study CoLAB with practice-based perspective, with a pragmatic purpose to illuminate the educators in transition.

In the beginning of INTRODUCTION, we use examples in our daily lives to illustrate the new “open wicked problems”: what are they? What are the features of “open wicked problems”? And why are they changing the pressing problems of our time? We then review the traditional learning models and the challenges it faces when solving open wicked problems. The challenges have resulted in new learning models, exemplified by a group of new learning initiatives around the topic of SDGs, one of which, the SDGo competition is introduced in detail so that we know what exactly the new learning model is. At the end of this chapter, we summarize the problems that we aim to solve in this thesis – we want to better understand the process of CoLAB with a practice-based perspective and we try to develop an analytical tool for practitioners who have trouble in understanding and implementing the new model of learning.

● PART I. LITERATURE REVIEW AND METHODOLOGY

Though the CoLAB is new, it takes roots in different theoretical and practice-based research in the literature of education and learning sciences. We specifically review two key concepts of CoLAB, i.e. collaboration and boundary-crossing, and their crossing with the concept of “learning”. The concept of “collaboration” and “learning” was not interrelated in the traditional education practice and research, which mainly took an individual and competitive paradigm. The study of “cooperative learning” began to analyze the phenomenon of learning in a team and has generally proved its better performance than individual learning. The study of “collaborative learning” stepped further trying to understand the learning as a process to co-construct knowledge based on constructivism. The focus shift to the process, the interaction and the socio-cultural aspect of learning in the form of collaboration. The crossing between “Boundary-crossing” and “learning” are most in interdisciplinary practices, as the disciplines are the most important form of boundary in education and learning. We review different forms of interdisciplinarity, their respective philosophy and their impact on CoLAB. In addition to the discipline boundary, we review expansive learning which transcends boundaries based on learners’ prior experience and social existence.

We apply the constructivist grounded theory (C-GT) in our thesis. In PART I, we review specific methods of constructivist grounded theory as well as the constructivist paradigm of qualitative research methodology in general. The constructivist paradigm of qualitative research method constructs the interpretive knowledge of the social actors’ action, thoughts and their social and cultural context through empathizing, understanding and interpreting. Therefore, the researcher’s social and political existence, viewpoints, purpose and interests are important parts of construction of reality. The rationale of using the constructivist qualitative research is explained in chapter 4.2: both

the researchers' practice of facilitating different background participants and the learner centered CoLAB learning itself require the researcher to take a constructivist perspective. Therefore, the constructivist qualitative method matches the research content. More specifically, we apply the constructivist grounded theory for constructing the knowledge of CoLAB. The grounded theory method has the advantage of generating theory from practice matches our practice-based motivation, and the pragmatic purpose is also one of the key pursue of research based on grounded theory. In the last part of PART 1, we introduce in detail the method of constructive grounded theory (C-GT), which include a general introduction of the different components of the C-GT, as well as a step-by-step procedure of C-GT with the examples from Charmaz(2006). This will help readers who are not familiar with the C-GT method to better understand how we construct the knowledge from the front-line practice and finally generate the theory.

● **PART II. THE DISCOVERY OF CO-MEANINGFULNESS IN COLAB.**

Our main analysis starts from Part II. The first part of PART II (Chapter 5,6,7) focuses on the socio-cognitive process of CoLAB, which means the microscopic collaboration and learning is at the center of our focus. The case of “Jumping Video” is purposively sampled as it contains complex challenges and rich interactions in overcoming the challenges. The data includes a full transcription of conversation of the 4-day workshop as well as post interviews of the participants. If the reader is interested in the detail of the “Jumping Video”, it is recommended to read the full transcription, otherwise we provide a brief introduction to the “Jumping Video” project including the workshop, the mentors, participants, and the general process of the workshop and result. The analysis follows the method of constructivist grounded theory with a three-step coding and conceptualizing. The “Co-Meaningfulness” emerges as a key concept in the coding and conceptualizing when students find it not enough just communicating on the “project” level, and that they have to communicate and negotiate which part of the project is more “meaningful”. The phenomenon of constructing “Co-Meaningfulness” is discovered as an underlying but significant process in CoLAB learning, especially salient when the group faces challenges in the collaboration. “Meaningfulness-Meaningfulness Coherence” (“M-M Coherence”) and “Project-Meaningfulness Intensity” (“P-M Intensity”), as two properties that characterize “Co-meaningfulness” are discovered through comparative analysis in finding out why and how their “Co-meaningfulness” changes over time. The “M-M Coherence” means how coherent the group member’s meaningfulness are related to each other. The “P-M Intensity” means how actively group members engage their meaningfulness into their project - e.g. are they fully engaging or are they compromising their meaningfulness, are they efficiently communicating their meaningfulness so that it will influence the joint project, etc. These two properties are then used as two axes to build up the “Co-

Meaningfulness” quadrant map where the CoLAB process can be anchored with a Co-Meaningfulness trajectory. The “Co-Meaningfulness”, the properties of “M-M Coherence” and ‘P-M Intensity” and the Co-Meaningfulness trajectory are the key results when we take a socio-cognitive perspective in understanding CoLAB.

Only the socio-cognitive perspective is not enough in understanding CoLAB. In the second part of PART II(chapters 8-11), we enter the socio-cultural aspect of CoLAB and the concept of Co-Meaningfulness, which concerns who these learners are, what they bring from the past learning and how do they engage them in the CoLAB, and what impact will the learning has upon the future and the development of the learner. By incorporate these issues, we will complete the grounded theory with a special focus on the socio-cultural perspective. We continue to use constructive grounded theory for this perspective. We use data based on an ethnographic study of a workshop series over one year, among which two typical workshops in the series are highlighted. Data includes notes, memos, voice recordings, formal and informal interviews, all documented in the appendix. Again, if readers are interested in the detailed ethnography, they can refer to the data in the appendix, otherwise, we also present a brief ethnography of the workshop series in the beginning of this part.

Through analysis with grounded theory, we generate the basic pattern of “Evoking” and “Applying”, which means that the meaningfulness is not purposely created to fit the “Project” at hand, but generated when learners evoke a (or multiple) socio-historical “Project” and apply its socio-cultural “Meaning” to the current Project, and the underlying pattern of “Prioritizing”, which determines what “Project” to evoke and what “Meaning” (and how) to apply. With this understanding, Co-Meaningfulness is not only concerned with “Project” and “Meaning”, but also a clashing of different learners’ “evoking” “applying” and “prioritizing” process. With focused coding, we are able to conclude a three-level framework of “Co-Meaningfulness” from both the socio-cognitive and socio-cultural perspective, which provide an easy analytical tool for practitioners with which they can diagnose their CoLAB learning.

In the concluding chapter 12, we conclude the whole grounded theorizing journey – how we develop from the first set of categories and complete the framework with socio-cognitive and socio-cultural perspectives, with a consistent visual presentation.

● CONCLUSIONS

In the CONCLUSIONS, we first summarize the whole thesis—the background, the motivation, and the questions and how our results of Co-Meaningfulness

is an answer to these questions. We then conclude our key contributions of this thesis and the framework of Co-Meaningfulness: 1. Co-Meaningfulness helps to identify and understand the key challenges in CoLAB; 2. Co-Meaningfulness helps to understand the developmental role of CoLAB and help catalyze the chain reaction of CoLAB. We finally present the prospects of using “Co-Meaningfulness”. Besides the two main contributions, we propose using Co-Meaningfulness as the basis for developing further grounded theory for other topics concerning CoLAB, and for extending to objectivist and big-data based study.

PART I. LITERATURE REVIEW AND METHODOLOGY

In the INTRODUCTION we introduced the general background of this thesis: the “Open Wicked Problems” are challenging our current learning and education system, and the new learning models are emerging to face these challenges. We specifically focus on a new form of learning featured by “collaboration” and “boundary-crossing” in solving the “open wicked problems”, which we name the “CoLAB”. In the INTRODUCTION, we have discussed the “open wicked problems” and their relation to the new learning model, while in PART I, we will review the historical research related to the other two features of CoLAB, namely the “collaborative learning” and “boundary-crossing learning”, in order to frame our topic – the CoLAB - in the research literature. As CoLAB is by itself a wicked problem, the related literature also covers a variety of research based on different theoretical and epistemological grounds. The literature review is an integration to frame and illuminate our research on CoLAB.

In Chapter 1, we review the field of collaborative learning and their relation to CoLAB. Under the name of “collaborative learning”, there are actually different perspectives in understanding the phenomenon of “people learning together”. The different perspectives reflect their different focus and epistemologies. The “cooperative learning” perspective focus on “intervention” and “performance”, which mainly bases on an experimental psychology paradigm. The “socio-cognitive” perspective focus on the interaction and the process of knowledge constructing through interaction, while the “socio-cultural” perspective regard learning as a social activity, focusing on its role in a wider context, e.g. regarding learning as a social activity to participate in a community. Both the “socio-cognitive” perspective and “socio-cultural” perspective

In Chapter 2, we review the research related to the feature of “boundary-crossing”. The first boundary we discuss is the disciplinary boundary. The study of interdisciplinarity categories the different forms of boundary-crossing in interdisciplinary learning. Besides the disciplinary boundary, in CoLAB, learners often have different social, cultural and political background, and these differences based on learners’ prior experience and social existence set up the secondary boundaries for the learners, which they will need to cross in the collaborative learning. We further review the field of “expansive learning” which focus on transcending the second boundary of learning. The historical study of “Collaborative learning” and “learning across boundaries” provide a broad research background for CoLAB to get theoretical inspiration from. At

the same time, as an emerging learning model, the study of CoLAB also points out some promising new directions for these fields of research.

As this thesis is a grounded theory study, the function of the literature review is different from a traditional social research based on deduction. The general roadmap of this research is “bottom-up” rather than “top-down”, meaning that we start with our ethnographic data, analyze them, and finally generate our grounded theory. The literature review here does not serve as the theoretical frame from which the researcher selects one theory, makes hypothesis and then tests with empirical data. Instead, the literature here introduces the prior network of research that are relevant to our research focus and questions, framing the research of CoLAB and its contribution in the network, and at the same time to facilitate the researcher with in-depth theoretical sensitivity when I conduct the grounded theory. Therefore the literature we review here are all important references and theoretical inspirations, but not necessarily theoretical frame that we follow in deducing and testing.

In this thesis, we conduct qualitative research methods in studying the CoLAB learning. Qualitative method in general is reviewed in Chapter 3, followed by Chapter 4 which reviews the specific method of constructive grounded theory.

Chapter 1. Collaborative Learning

The history of learning and education is mainly based on an “individual” and “competitive” model. Students learn in a classroom, everyone with their own textbook and assignment. Exams follow when everyone sits by themselves, answering their exam paper which is to be graded for individual learning success or failure. “Collaboration” is most absent in the learning scenario.

But since the 1970s, “collaboration” becomes more and more significant in learning, because we more and more rely on collaboration in working situations, which pushes educators to regard collaboration as an important aspect in education. The research field of Collaborative Learning is an interdisciplinary field focus on individual and group learning in collaborative scenarios. Researchers from a variety of disciplines study how and why group learning works (or not), with their qualitative, quantitative or mixed tools (including research from educational psychology, social psychology, learning sciences, and sociocultural theories). Their research attracts a growing attention from education researchers and practitioners, as the ability to collaborate and to learn in collaboration is becoming a key competence in the 21st century. As our topic, the CoLAB study, falls into the general “Collaborative Learning” topic, it is necessary to review the status of CL

research in order to understand how CoLAB study can be framed under this overarching research field.

What is “Collaborative Learning” and what is the research of CL about? This simple question however does not have a simple answer. When reviewing the field of CL, one can find out the center research topic or research question is divergent due to the multidisciplinary nature, with different waves of CL research during the past decades. These different waves are ultimately due to the different understanding of “learning” itself, as Wenger(1999) explains:

“There are many different kinds of learning theory. Each emphasizes different aspects of learning, and each is therefore useful for different purposes. To some extent these differences in emphasis reflect a deliberate focus on a slice of the multidimensional problem of learning, and to some extent they reflect more fundamental differences in assumptions about the nature of knowledge, knowing, and knowers, and consequently about what matters in learning.”
(Wenger, 1999, p. 4)

The first wave of “Collaborative Learning”(CL) research emerged in the name of “**Cooperative Learning**” as a special topic in educational psychology(Johnson & Johnson, 2009). Although now many researchers distinguishes cooperation from collaboration(Baker, 2015), the early “Cooperative Learning” research is a unneglectable part of CL research. Therefore, we use of “CL / Collaborative Learning” to represent the field in general, but not excluding the research effort under the name of “Cooperative Learning”. The early “Cooperative Learning” studies mainly in-class scenarios where students are guided to learn in groups (Slavin, 1996). This pedagogical method was compared with individual or competitive models where students in-class are only responsible for their own learning performance (or overperforming others in a competitive model). Johnson et al.’s meta-analysis (Johnson et al., 2000) of over a hundred of research work has been demonstrated that the model of “group learning” is in general better than individual/competitive model in terms of performance(Johnson & Johnson, 2009). This successful research story has inspired many researchers to follow the trend and conduct their own experiment to find out what kind of interventions helps in CL, why and how they can help. A large number of research as well as intervening methods have been proposed making a significant contribution to the CL research.

But as we step into the new century, educators emphasize not only on the traditional performance but also more complex competencies such as collaborative creativity (Sawyer, 2012)(Hämäläinen & Vähäsantanen, 2011). This change has called more and more interests in the **constructivist view** of

education rather than the traditional instruction-based view. It is true in cooperative learning wave many have referenced Piaget and constructivism, but the emphasis is mostly seeing cooperative learning as instruction method, not necessarily as learner centered and constructivist. However, the new education promoting learner centered pedagogy, e.g. Project Based Learning, is not the key emphasis of Cooperative learning. Constructivist view pays more attention to student's own cognitive process in constructing knowledge other than passively accepting, understanding and transferring knowledge (Reusser et al., 2015). When taking a constructivist view on CL, researchers are naturally not satisfied with studying invention and performance but instead interested in understanding in-depth the cognitive process of individual and group in constructing the knowledge. Among the researchers with this view, two perspectives are most salient: **1.** the constructivist developmental view originated from Piaget pays close attention to **cognitive process** in CL scenarios with clinical observation (Golbeck & DeLisi, 1999), and **2.** influenced by Vygotsky's **social-culture** development perspective, many have extended social-cultural theories into the CL research (Wells & Claxton, 2008). These two perspectives together with the educational psychology tradition are considered to be the most active perspective in CL research. In the meantime, CL research also takes in according methodologies as necessary tools. These methods are aligned with respective world views and epistemologies, e.g. scholars who share the sociocultural perspective adopts an ethnographic method in studying the cultural influence on the collaborative learning, while those who focus on the socio-cognitive perspective adopt methods based on interactionism, such as conversation analysis.

The three waves of CL research all have significant contribution in understanding the phenomena of "Collaborative Learning". But they stand on different ontological stance in understanding what is "Collaborative Learning" or more deeply, what is "learning", applying different epistemological tools in studying the phenomena.

In the chapter 1.1, 1.2, 1.3, we will respectively review the "three waves": "Cooperative Learning", "Socio-Cognitive Perspective" and "Socio-cultural Perspective". We will give context of their respective theoretical ground, major topics and results, and their research methodologies.

1.1 The "Cooperative Learning" Perspective

The Questions of Cooperative Learning

The early effort of the "experimentalist" who study students learning in a group often use the name "Cooperative Learning". The Cooperative Learning

Perspective is an early research effort in educational psychology/educational research majorly focusing on “learning in groups” as a pedagogical method in classrooms. A typical Cooperative Learning scenario is teacher asking students to learn in a small group by setting up specific goals with specific cooperative learning procedures. This scenario was not a popular method several decades ago. Dating back to the 1970s and before, the strong competitive model and focus on individual development was the dominant method in pedagogy (Johnson et al., 2000). Since the 1970s, thanks to CL practitioners and researchers’ continuous efforts, cooperative learning has gradually grown importance and now it has become an indispensable method in education. Its use, as we all observe, permeates to K12 and university education around the world.

The research of Cooperative Learning, growing together with the blooming of the pedagogical practice, asks question about (1) Why learning in groups work (or not), especially comparing to the “individual” or the “competitive” model widely used in traditional class; (2) How can we improve the pedagogy, e.g. can how teacher make better instructions to facilitate cooperative learning, etc. (Slavin, 1996)

These questions reflect a common understanding of Cooperative Learning research, that an effective cooperative learning is much more than just putting students together. A lot has to be considered concerning students social-psychological status and individual learning process. What social psychological status promote meaningful interaction that leads to learning? What instruction process help students to conduct better social activities? Etc. Cooperative Learning researchers envision to decode these questions by understanding the mechanism behind the cooperation and by testing interventions in class with different conditions.

Now, with a century’s development, especially the blooming since the 1970s, the Cooperative Learning research has developed substantially, as researchers claim it to be “*one of the greatest success in the history of educational research*” (Slavin, 1996, p. 43). The collective research efforts have evidently shown **that the cooperative learning method in general overperform the “individual” and the “competitive” model.** (Slavin, 1990)(Johnson et al., 2000)(Gillies, 2016)

Or simply put, people learn better when in a group. This growing consensus can be better elaborated by answering the following key questions:

- What do we mean by “better”?
- Under what condition do we mean by “learn in a group”?
- Why “people learn better when in a group”?
- How can people learn *even* better than just *being* in a group?

Answering the first two questions in “Cooperative Learning” Perspective gives context to Cooperative Learning research, while the last two questions describe the key research questions. We will give short answers to the first two questions and explain the essential findings for the last two questions in the following section.

First question, the criteria of “better” in “Cooperative Learning” Perspective is relatively concrete. Although some other dependent variables were sometimes considered (Johnson & Johnson, 2009), researchers largely use “Performance” to test and evaluate whether and/or how “better” performance occurs due to cooperative learning conditions (or not). This choice is nature and effective and especially useful when one wants to compare different research results. Meta-analysis in cooperative learning history to compare and evaluate different cooperative learning approaches, proposed and studied in more than 1000 research papers (Johnson et al., 2000). This large scale of research and meta-analysis would not be possible if not for the concrete criteria that determines a “better” achievement of the students.

For the second question, the condition of “learning in a group” is usually studied in a classroom setting in Cooperative Learning. The teacher encourages students to learn with their peer students (normally 2-5 students in a group) in a face-to-face manner. The mutuality (how deep student interact) and equality (are students in equal power) of the group learning vary from situation to situation (Slavin, 1996).

The third and fourth questions are however less obvious to answer. Cooperative Learning researchers have investigated for decades around this two questions. One most mature and most widely accepted answer to the “why” question concerns **the motivationalist perspective of Social Interdependence**. This perspective attributes the positive learning effect to a “positive social interdependence” situation where individual regards their own goal is dependent on the achievement of the team’s goal, therefore make efforts to help their peer to learn (Johnson & Johnson, 2009). This motivational perspective has inspired a large body of research which constitutes the major part of the “Cooperative Learning” Perspective.

The Social Interdependence Theory

Social Interdependence means when the outcomes of individuals are affected by their own and others’ actions (Johnson & Johnson, 1989).

Which in cooperative learning scenarios means that the learner's achieving individual goals is dependent on not only their own efforts but also their group members' efforts. The emphasis on *interdependence* differentiates it with the social *dependence* situations where only one-direction dependence affecting the result (member A affected by member B but not the other way around). A successful cooperative learning system needs to witness a *positive interdependence* situation, where group members perceive they can achieve their individual goal if and only if the goals of the group (as an entity as well as each individuals in the group) are achieved (Johnson & Johnson, 2009). Whereas an competitive learning situation might see the reverse – a negative interdependence, where member believe achieving their individual goal is dependent on the others failing to achieve their goals.

The motivational perspective has been used to answer the “why” question we propose in the previous section: Why “people learn better when in a group” ?

As explained by the social intercedence theory, group members, who understand their correlated goals, are self-motivated to BOTH help their groupmates and encourage their groupmates in making efforts to accomplish the learning task (Slavin, 1996). Therefore, many researches are concerned with structuring Common goal and reward are essential (Slavin, 1996). To be more specific, Researchers have concluded the following aspects as sub-mechanism of positive interdependence that accounts for better learning effect: the individual accountability and personal responsibility, the promotive interaction, the appropriate use of social skills, and the group processing (Johnson & Johnson, 2009).

- *Individual Accountability and Personal Responsibility*

The positive interdependence can create individual accountability and personal responsibility that motivate group members to make efforts (Deutsch, 1949). Once the positive interdependence is established, it create an obligation for the individual in the group to make effort and contribute to the group task. The obligation is not only for completing one's work, and more importantly to help and encourage others in the group to finish their share of work. This responsibility structure bond the personal responsibility to the group performance and therefore socially structured. Everyone feeling responsible for achieving their personal goals feels responsible for the group performance, which includes their group members' performance, if the group is positively interdependent (Wentzel, 1994).

- *Promotive Interaction*

The second mechanism that contributed to the group performance is promotive interaction. Promotive Interaction indicate those actions that

individuals encourage and facilitate other member in the group aiming to achieve their group goal.

As we have explained, the personal responsibility not only lead to a self-motivated learning but also a socially promoted learning. This socially promoted learning is implemented by promotive interaction. Aside from the socially coordinated responsibility, the interdependent reward structure is explained to be another reason for the promotive interaction(e.g. praise, encouragement base on members' efforts) (Slavin, 1983).

- *Appropriate Use of Social Skills*

Another important mechanism related to interdependence is the appropriate use of social skills. Often regard one of the 21st century competencies, the ability to appropriately communicate social skills is essential to the cooperative learning and better performance. The positive interdependence promoting more appropriate use of social skills is another reason accounting for why cooperative model works. Researches have shown that group members who better know, trust and support each other overperform those do not(Johnson & Johnson, 2009).

Scholars sometimes relate this element of social interdependence to the concept of "social cohesion", in which they explain the motivation for the group does not only exist in the "group goal" or "accomplish the task" but to be for the good of the group per se. Therefore, the more cohesive the group is, the better they will perform because the students will help each other to learn as they care about each other (Slavin, 1996).

The social skill aspect of interdependence justifies teambuilding activities before and after the cooperative learning, a direct way to train the appropriate use of social skills and to improve the social cohesion(Cohen & Lotan, 2014)(Sharan & Sharan, 1992).

- *Group Processing*

Group Processing means members reflect on the cooperative process in order to understand which actions benefit the cooperation and thus the learning in general and which actions are not helpful. The group process is a socially coordinated action resulted from interdependence and in turn iterate and improve the interdependence structure. Research has found out that the group process help increase not only performance but also motivation, social cohesion in the group, and members' self-esteem(Archer-Kath et al., 1994). The group process sometimes are teacher induced and sometimes student initiated. Research has found out the combination of both instructor-comment-format and student-discussion-format processing overperforms either process alone or no process at all(Johnson & Johnson, 1989).

To conclude, the social interdependence has been widely applied by many researchers in explaining why they are effective in terms of better

performance, especially comparing to individual and competitive model. These researches focus on how the motivation and reward structure have influence on the social-psychological status of the group and therefore influence the cooperative learning through different sub-mechanisms such as personal responsibility, promotive interaction, appropriated use of social skills and group processing. These elements are key to structuring positive interdependence(Johnson & Johnson, 2009), and hence key to establish a successful cooperative learning: in the end, cooperative learning is much more than just putting students together.

How can people learn *even* better than just *being* in a group? The fourth question is a pedagogical concern. When theorists have given and proven relative theoretical inspiration, the next question comes naturally around “how to achieve such success”. In the study of cooperative learning, there are not only interests in understanding “why it works”, but also great interests to actively creating and testing pedagogical methods based on the understanding of the “why” question. “Researcher-developers” (Johnson et al., 2000) see the relationship between practice and theory as a two way relationship, in which practice is guided by theory while theory is improved by the practice.

Many pedagogical methods have been proposed during the past decades and are tested with lab experiments or field studies. The following reviews methods that have been largely applied and studied in the literature, mainly in the north America during last decades:

- *Complex Instruction (CI)*(Cohen & Lotan, 2014),

The Complex Instruction (CI) Method was developed mainly for heterogenous classrooms. The purpose of CI, besides promoting cooperative learning, exist in increasing equality in the cooperation. Many have observed situations where students learning in groups do not work equally as they are inherently heterogenous in terms of ability, knowledge, intelligence, etc. CI is purposed to confront this issue by introducing: (1) curricula that encourage higher-order thinking, often around a central topic/concept that is open-ended and requires multiple ability of the students. (2) specific instructional strategies that facilitate the students to better participate with cooperative norms and role play etc.

The CI methods emphasize *Every* member in the cooperative should learn with equal access and opportunity, regardless of their inherent differences. The complex central topic makes sure no any group member with specific outstanding knowledge can be the “dominant star” who prohibits others’ voice or chance. The complexity also ensures students of diverse abilities can participate with their advantage. CI requires teachers to specific care about

unequal situations and treat the team status with instructions that convince students everyone can make important contributions to the learning.

- *Constructive Controversy (CC)* (Johnson & Johnson, 1979)

The Constructive Controversy (CC) approach focuses on the controversy emerging from the cooperation. The phenomena of “Controversy” indicate situations when one group has incompatible ideas, concept, or conclusions, etc. with another member of the group. And the Constructive Controversy requires the two with conflicting view to try to constructively resolve the controversy and reach an agreement. And the learning happens in the process of resolving.

From cognitive perspective, the situation of “controversy” introduces a disequilibrium of inter-personal cognition in the group, and therefore stimulate “epistemic curiosity” of individual to explore another individual’s conflicting ideas, concept and thoughts, which is a starting point for new insight and discovery.

The Controversy situation is an opportunity for learning if appropriate “controversy mediation” is present. For example, researchers find strategies such as “perspective-taking” effective compared to “egocentrism”(Johnson & Johnson, 1979). Other condition include cooperative context, skilled disagreement, rational argument, and active participation, (Johnson et al., 2014), etc.

- *Group Investigation (GI)* (Sharan & Sharan, 1992)

The Group Investigation focus on “investigation” in group form as the major part of learning. In group investigation, students actively participate in the investigation and teachers facilitate the group investigation in more interactive ways than whole-class instruction. The GI method is featured by 6 steps in 3 stages. In the first stage, students main identify an center topic for their investigation while forming and organizing their group. The second stage is remarked by activities that plan the investigation, followed by a third stage when students actually implement the investigation. Steps in the first stage is most complicated, which include (1) an exploratory step where teacher present a board and multifaceted theme; (2) students formulating and choosing different subtopics by e.g. asking questions; (3) Teacher giving and presenting suggestions to the sub questions; (4) students categorizing their questions; (5) students reviewing all the questions proposed and joining the group whose subtopic they are most interested in. The GI method leave space for student to investigate with own interest, and have been proved effective in academic performance with several studies. (Sharan & Sharan, 1990)

- *The Jigsaw Classroom* (Aronson et al., 1978),

The Jigsaw Classroom(Jigsaw) is a pedagogic technique developed for better small group interaction in cooperative learning. The Jigsaw proposes, just like the jigsaw puzzle, that every piece would contribute an indispensable role to the whole picture - every student is like the every piece. In the Jigsaw method, 5-6 students form the “Jigsaw group”, where each member learn only one segment of the whole lesson. Then the students break the “Jigsaw group” and form temporary “expert group” with whom learn the same segment. Therefore in the “expert group”, all the members learn the same segment, and they have to exchange and prepare how they can present to their original “Jigsaw group” so as to finish the picture(the jigsaw puzzle). In the last step, “expert group” breaks up and students go back to their own “jigsaw” group and present what they learn. As each of the member own one part of knowledge, everyone is important for the “jigsaw group” to get a whole picture of the entire class.

- *Student Teams Achievement Divisions (STAD)* (Slavin, 1978),
The Student Teams Achievement Divisions method (STAD) takes the motivational interdependence directly into practice. STAD structures a reward system that reward the individuals with the average score of the group. In STAD, students work in a group on task provided by the teacher. The next step, students take individual quizzes on the task. The individual score is however not the final destination of the individual, they have to make sure everyone in the group improve their score and learned. Therefore, the main activity in the group is socially structured because of the reward. Team members focus on helping each other on explaining, practicing and encouraging their peers.
There are many approaches that have existed in the cooperative learning history and the above ones are only small part of the pedagogy.

To conclude, the Cooperative Learning Perspective during the past century was an important reference to the Collaborative Learning Field. Although many research was done under the name of “cooperative learning” and some researchers try to distinguish the cooperation from collaboration, there are clear overlaps in the field. One most prominent contribution of Cooperative Learning is that with some hundreds of study, researchers have evidently shown the effectiveness of “learning in a group” compared to “learning alone” or “learning competitively”. More research have been done to examine which invention works and why.

The social interdependence theory is set as an most important explanation for the “Cooperative Learning” perspective. It not only give reasons to the why question, but also guides practice.

Some warns that the cooperative learning research should not reduce to singular perspective. E.g. in the review of the future problems of cooperative learning, Slavin writes:

"In particular, there are researchers who emphasize the changes in incentive structure brought about by certain forms of cooperative learning, while others hold that changes in task structure are all that is required to enhance learning. The problem is that applications of cooperative learning typically change many aspects of both incentive and task structures, so disentangling which is responsible for which outcomes can be difficult." (Slavin, 1996, p.44)

1.2 The "Socio-Cognitive" Perspective

The second perspective arise with the idea that Collaborative Learning is "centrally concerned with meaning and the practices of meaning-making"(Koschmann, 2002, p.20).

Seeing "collaborative learning" as the practice of meaning-making immediately brings a new perspective. The traditional perspective on education regards "learning" as essentially a knowledge acquisition practice(Sfard, 1998). Knowledge is transmitted from more knowledgeable agent to the less through instruction. Following the "acquisition" metaphor of learning, collaborative learning is no more than knowledge acquisition in a group setting. But the notion "meaning-making" is inherently different, it places the learner to the center of "learning" activity and highlight learners' role in constructing knowledge. This view aligns with the constructivist developmental view of learning, from Piaget to Vygotsky. (Piaget & Cook, 1952)(Vygotsky, 1978). Following the "meaning-making" metaphor of learning, collaborative learning is a process where the group of learners construct their joint knowledge through group meaning-making(Koschmann, 2002).

From the study of "outcome" to the study of "meaning-making" marks a great change in the focus of CL research. The "Cooperative Learning" studies pay a great attention in comparing predefined "Learning Performances" with different predefined conditions. But the process through which these different conditions occur is very much left examined like a "black box". While in the "meaning-making" view, learning outcome is less important than the socio-cognitive process. How do they learn through meaning-making? How does interaction help them to (co-)construct knowledge? These questions all concern the center process in the second perspective: the **socio-cognitive process** of collaborative learning.

The change was a result of the recent trend of a "learner-centered" view on learning, particularly in studies highlighting **new technology** interacting with human, such as Human Computer Interaction(HCI), Computer Mediated Communication, Computer Supported Collaborative Work, and Computer Supported Collaborative Learning(Hmelo-Silver, 2013). In HCI field, for

example, Suchman proposed the concept of situated action that no longer regards interaction as universal cognitive process planned beforehand but situated actions happening between agents (Suchman, 1987). In CSCL, the introduction of technology as medium challenged the traditional teacher-student paradigm. For example, Roschelle and Teasley studied students learning physics concept, namely “velocity” and “acceleration”, through a gamified computer program (Roschelle & Teasley, 1995). There are no traditional teachers in the learning scenario and the two students have to play the game to learn. All the learning process is through their interacting with the computer as well as between themselves. The absence of teacher and instruction immediately place the “socially coordinated actions” at the center of investigation: how do they communicate with each other through playing? What actions and interactions marks learning through collaboration? With an in-depth micro-analysis on the conversation and interaction in great detail, they concluded that the students’ co-constructing a “Joint Problem Space” is the core activity of their learning and cognition (Roschelle & Teasley, 1995). This particular emphasis on **socio-cognitive process** is a typical paradigm of the second perspective on Collaborative Learning, which substantially differ from the traditional educational perspective that compares and evaluates the learning outcome: students’ achievements.

Besides the shift in research focus, the Socio-Cognitive Process Perspective brings in a few other distinguishable changes to “Collaborative Learning”: 1. It is fundamentally linked with the co-constructivist view on learning 2. It brings the division between collaboration and cooperation 3. It has a strong zooming in intention.

The (Co-)Constructivist View of Learning

The constructivist view on learning focus on the learner’s constructing knowledge while constructing their mental structure from interacting with the environment. In this regard, constructivist pedagogy is often related to project based methods. Learners learn in a self-directed hands-on activity while constructing their knowledge and knowledge structure (Piaget & Cook, 1952). The co-constructivist view of learning regard the construction as not isolated to one learner, but in a shared space of knowledge and society and culture and through interacting with their peers (Reusser et al., 2015).

The constructivist view on learning is not entirely absent in the first perspective (Johnson & Johnson, 2009), which however doesn’t directly reflect the core of constructivist view. The socio-cognitive trend to the opposite directly investigate how students co-construct knowledge in a group..

The Co-constructivist view of learning brings a two-fold change to collaborative learning. The first, as we have elaborated, lies in the shift in research focus, while the second, lies in the pedagogical shift towards “learner-centered” direction. Again, the learner-centered is not entirely absent in the “outcome” study, in fact, we can find traits of “learning centered”, “project-based learning” in many approaches. But this “learner-centered” approach is not the purpose of practitioners in the first trend. The purpose is to adopt and compare predefined methods and evaluate better/worse performance. But this to some degree contradicts the constructivist “learner-center” view that to a great deal centers student’s active construction with their prior knowledge. The process is studied with and through the student’s in a situated way and has the intention to escape universality deduced by outcome, while the process is a black box.

Collaboration as Deeper Mutuality

The second perspective of “Socio-Cognitive” is at the same time manifested in the change of the name of the field: from “cooperative” to “collaborative”. The differences between the two notions were mentioned by Roschelle and Teasley (Roschelle & Teasley, 1995) and elaborated by (Baker, 2015). In short, researchers of the second wave perspective, regard cooperation as a larger concept in which students learn through working together, e.g. through labor division, while collaboration indicating scenarios where students deeply exchange on the ideas of the problem from the beginning (Baker, 2015). This consensus implies a shift in the focus of CL research: from low-level mutuality to high-level mutuality.

Roschelle and Teasley define “Collaboration” as “a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem (Roschelle & Teasley, 1995, p.70)”. This definition later on has been largely referenced in the Collaborative Learning field. In his elaboration, they specially distinguish Collaboration from Cooperation in that collaboration emphasizes on the deep interaction, and co-construction of a joint problem space.

Baker (2015) elaborated further on the difference with the following imagined example:

“The (invented) example of three students (X, Y and Z) writing a short joint project report on flora and fauna in their local park will help to clarify this distinction between cooperation and collaboration. Students could

cooperate on this joint task, in the sense of working towards the shared goal of producing the report by dividing up responsibilities for achieving subtasks: for example, “you, Y, write up the data; you, Z write the references and describe the park; I, X, will write the introduction and conclusion”. Or they could collaborate, in the sense of studying the park, analysing data, writing the report together, side by side, from beginning to end, discussing as they go along, with respect to what they are trying to do, how they should do it and what is meant by elements of the task (such as “flora”, “the park”, “the report”).” (Baker, 2015, p.6)

In this regard, the researchers taking a “socio-cognitive” perspective also see the process of collaboration as mutually more in-depth than the process of cooperation.

The Intention to Zoom in

As we have mentioned, “Cooperative Learning” study of collaborative learning regards learning as a kind of black box, and the study in general compares different black boxes by evaluating the performance predefined. To the contrary, the “socio-cognitive” perspective has the strong intention to zoom in and to open the box.

The intention to zoom in leads to the application of “micro analysis”, which focuses on the micro scenarios of group interaction. In Roschelle and Teasley’s seminar work of collaborative learning (Roschelle & Teasley, 1995), they studied different micro scenarios with only two students interacting in great detail. This focused micro analysis of dyad cases is not common in traditional educational research of “cooperative learning”. In cooperative learning, usually the study takes relatively longer time, and the outcomes is carefully examined with different conditions. But in the wave of “Collaborative Process” perspective, study of shorter period interaction with methods such as conversation analysis is more salient.

The zooming in perspective resonates the constructivist perspective that the CL is a study of the construction process rather than a study of “outcomes”. It is not only about give explanation to what leads good performance but also the process that leads to the results with an eye to zoom in.

The intention to delve deeply into the interaction can be seen from Suther’s concept of the “Intersubjective learning”:

“A more radically interactional epistemology, which I shall call intersubjective learning, goes beyond an information sharing conception of collaborative learning in two ways: it can be about sharing

interpretations as well as information, and these interpretations can be jointly created through interaction, in addition to being formed by individuals before they are offered to the group" (Suthers, 2005, pp. 662-663).

The model of "intersubjective learning" not only concerns the interaction of information in the learning but also the interaction of interpretations. This epistemology of collaborative learning is one step further to the interactional model, which researchers take insightful and zooming in perspective into the socio-cognitive process.

1.3 The "Socio-Cultural" Perspective

From "Socio-cognitive" to "Socio-Cultural" perspective

The "Cooperative Learning" perspective does not focus on the "meaning-making" process which is a key element for the constructivists. The "Socio-Cognitive" perspective highlighting the "meaning-making" as essential for learning, however misses the perspective of the situated context where learning happens. Is analysis of merely "individual and interactional cognition" enough in understanding the collaborative learning? Some researchers do not agree.

The collaborative learning process should not be analyzed without looking at the social and political context where learning happens. How can we well understand the meaning behind the conversation without understanding the social and political context? How can we understand the verbal and non-verbal communication without a deep insight on the community? How can we infer the tacit knowledge without merging in the culture?

That's why the "Socio-cultural" perspective places the social context at the center of Collaborative Learning research and understand learning as essentially a social practice inseparable from its real life situation.

The Sociocultural perspective is radically different from the previous perspectives. It is different from the "Cooperative Learning" perspective as it emphasizes the emergent meaning-making aspect of learning rather than predefined evaluation of controlled conditions. But it is also different from the socio-cognitive perspective as they believe the meaning-making should be studied in a wider social context. The natural context in which learning occur gives meaning to the situated practice.

Apparently, this perspective takes a holistic view on learning. They are not satisfied with the reduction of learning activity to only “outcomes”, “cognitions” or “interactions”, but also ask questions about their social existence and relationships in their natural setting:

What are the social and political context of the learning?

Who are these people learning, for what purpose?

What are their relationship in the collaborative learning?

What are the functions of the cultural tools they use in the communication and learning ?

How does learning take place as a community practice? Etc.

The situation in which learning occurs is a complex issue. For example, Fjuk and Ludvigsen introduced the complex elements affecting the “distributed collaborative learning” (collaborative learning distributed through time/space/other medium or tools, etc.) are interconnected:

“distributed collaborative learning is a product of complex interconnections between several aspects, such as: theories of learning and instruction, subject domains, teacher’s roles, delivery institution’s educational praxis and tradition, organisational and administrative arrangements, costs, properties of ICT (information- and communication technology) and available software, geographical distances between co-learners, etc. Any changes associated with one of these aspects will inevitably influence and change the others.”(Fjuk & Ludvigsen, 2001, p.1)

The intention to include the many elements from “theories of learning and instruction” to the “geographical distances between co-learners” is a typical concern for the sociocultural perspective. Experiments or conversation analysis only reflects part of the whole story. The interconnecting nature of the elements as they presents in the example also brings extra complexity to the perspective. The main task for socio-culturalist of collaborative learning is to structure the real-life complexity to cast light to the situated collaborative learning.

Why does researchers introduce this perspective? The motive for understanding learning in real-life situations differs from the first two perspectives. In the “cooperative learning” perspective, the main purpose is to understand the “cooperative” model versus individual / competitive model, and to design interventions that can evidently bring better performance. The socio-cognitive perspective is to understand how learners interact and how to facilitate especially with the intruding of technology that tremendously changes our ways to interact to each other. The third perspective however intend to cast light to the individual history, the environment, the community that impacts the learning. The purpose in itself expands the scenarios from

school going scenarios to more general situations where learning can happen: In companies, hospitals, competitions or even at home with families. In a word, learning in informal scenarios and lifelong learning scenarios are a constant topic in the third perspective, as Wenger put in the book “Communities of Practice”, the socio-cultural perspective does not pretend learning is: “an individual process, that it has a beginning and an end, that it is best separated from the rest of our activities, and that it is the result of teaching” (Wenger, 1999, p.3). But it instead “our lived experience of participation in the world is as much a part of our human nature as eating or sleeping, that it is both life-sustaining and inevitable, and that — given a chance — we are quite good at it? And what if, in addition, we assumed that learning is, in its essence, a fundamentally social phenomenon, reflecting our own deeply social nature as human beings capable of knowing?” (Wenger, 1999, p.3)

In the third perspective, the motive to study collaborative is much bigger, learning is seen beyond the school, beyond the cognitive process, that is essential a question : How learning can be different from one to another community, from topic to another topic, from one structure of community to another? Are they the same or do we need to adapt according to situations?

In this regard, learning is “not a separate activity: it is not something we do when we do nothing else or stop doing when we do something else” (Wenger, 1999, p.8)

Socio-cultural Theories of Collaborative Learning

● The Origin: Vygotsky’s theory

Many researches taking this perspective owes greatly to the influence of the Vygotsky’s theory of learning, which eventually inherits from Hegel and Marx’s cultural theory. After Vygotsky, there are different anthropologist, ethnographer, social psychologist who adopts this perspective and develop their own theories and studies in this social cultural tradition.

The most relevant work in this tradition inspiring Collaborative Learning and the Learning Sciences is Vygotsky’s study of child’s learning and development (Vygotsky, 1978). Vygotsky posits that learning should be studied within the context of culture. A comprehensive analysis of child’s development should consist the study of the context in which the child and their family are situated in. Cultural tools, e.g. language, are essential features of such analysis. Children learn knowledge and develop their mental abilities through constant communication with cultural context mediated by cultural

tools and hence inherently “social”. For Vygotsky, “social” means not only the “social interaction” among more than one people, e.g. child and adult, but also the “social context” such as community and culture(Vygotsky, 1978).

The concept of “mediation” above mentioned is key to Vygotsky. An unmediated act might be a direct response to the stimulus(the S-R chain), but a mediated act is a more complex process where subject use the mediation “X” to respond to the stimulus. The middle “X” is the mediating tool, both physical tool such as a hammer and semiotic tools such as language, math etc. These tools carrying the cultural historical components are objectified knowledge accumulated in the culture evolution, useful in the S-R scenario. The mediation of cultural components will inevitable “draw” the subject to the more complex mediated act requiring higher order mental abilities. The appropriation of the mediating tools is one key feature of learning to Vygotsky(Vygotsky, 1978).

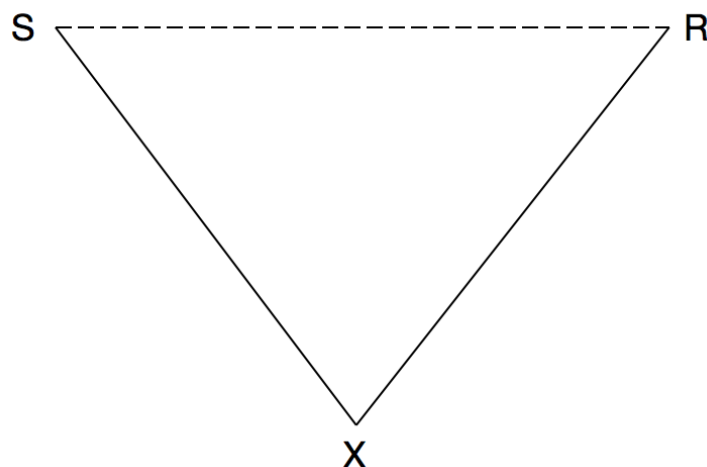


Fig. 1.1 Vygotsky's concept of mediation (Vygotsky, 1978, p.40)

Vygotsky then explain the appropriation of learning happens in the Zone of Proximal Development (ZPD), another key concept that has great influence on the field of Collaborative Learning. The ZPD is defined as “the difference between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers”(Vygotsky, 1978, p.86). Vygotsky posits that the learning happens when the subject is faced with problems, they cannot solve independently but solvable with the help with more capable peers through social interaction. To Vygotsky, the learning begins when the child interact with adult in their ZPD and appropriate the mediating tools needed for the scenario, and ends with their independently solving the problem.(Vygotsky, 1978)

Although Vygotsky's theory of learning development talks a lot on individual cognition as Vygotsky is himself a psychologist, it leaves rich heritage for the sociocultural way of thinking for its remarkable mention of social context and cultural tool as mediation. The concept of cultural evolution, mediated act and ZPD which Vygotsky developed from Hegel and Marx, has inspired a number of recent sociocultural progress. We will review a few of them to get a glimpse on the sociocultural perspective active in the state of art Collaborative Learning Research.

● Activity Theory

Activity theory was developed in direct relation with Vygotsky. As we pointed out, although Vygotsky's thinking is the starting point to the social turn of collaborative learning, Vygotsky still base his unit of analysis on the individual cognition and action, such as in the mediated action model. This model of "action" is useful but not enough to "account for the collective nature of human activities"(Cole & Engeström, 1993, p.7).

Activity Theory expands the individual concept "action" to the more social and collective concept of "activity". Leont'ev explains the mutual relationship between the two concepts of "individual action" and "collective activity" using a hunting example:

"When members of a tribe are hunting, they individually have separate goals and they are in charge of diverse actions. Some are frightening a herd of animals towards other hunters who kill the game, and other members have other tasks. These actions have immediate goals, but the real motive is beyond hunting. Together these people aim at obtaining food and clothing—at staying alive. To understand why separate actions are meaningful one needs to understand the motive behind the whole activity. Activity is guided by a motive. "

(Leont'ev, 1978, pp. 62-63)

And this concept "activity", instead of "action" constructs the basic structure of analyzing human activity in collaboration.

Activity theory extends Vygotsky's triangle to a multiple triangle model which consists 6 elements: Tools, Subject, Object / Objective, Rules of Interaction, Community, Division of Labor.

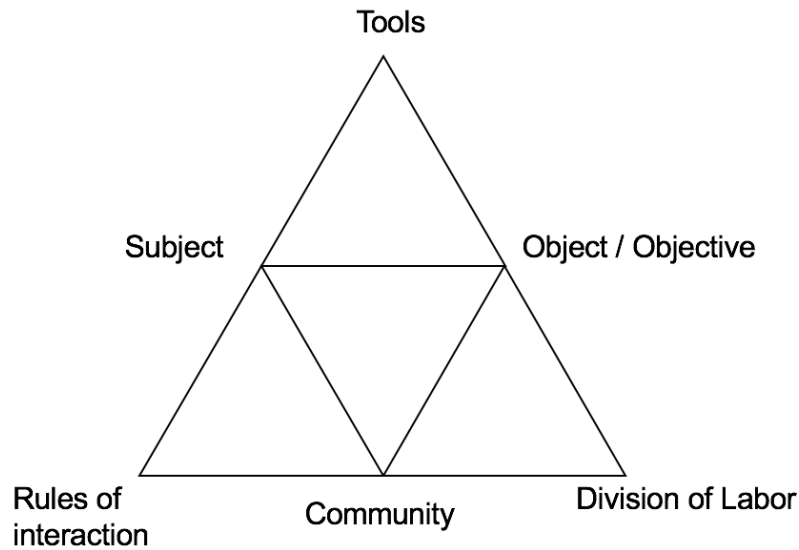


Fig. 1.2 Activity Theory Triangle System (Cole & Engeström, 1993)

Illustrated by the above figure(Fig. 4.2), the key elements of the activity system are the subject, the object and the community where subject and object exist. The tools are the mediation with which the subject approach the object, similar to Vygotsky's small triangle (Fig. 4.1). The subject interacts with the community with the rules of interaction of the community. The final element is division of labor, which presents the relation between the objects and the community: how tasks, powers are distributed(Cole & Engeström, 1993).

Activity Theory is used as a theoretical framework for analyzing the socio-cultural perspective of collaborative learning. It emphasizes on the mediating tools as well as the community's role in the activity, which is manifested in the rules of interaction and the division of labor.

● **Communities of Practice:**

The communities of practice theory regard learning and collaborative learning an important role in constructing a community of practice(Wenger, 1999).

Wegner defines the Communities of Practice as : *"Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly."* (Wenger, 2011, p.1).

The basic rationale to introduce Communities of Practice in the discussion of collaborative learning is, like the other socio-cultural perspective, to regard learning from a different view and relate learning to its situation and context.

For the Communities of Practice Theory, this situation and context is the Learning Community:

“Participation here refers not just to local events of engagement in certain activities with certain people, but to a more encompassing process of being active participants in the practices of social communities and constructing identities in relation to these communities. Participating in a playground clique or in a work team, for instance, is both a kind of action and a form of belonging. Such participation shapes not only what we do, but also who we are and how we interpret what we do.”(Wenger, 1999, p.4)

The primary metaphor of learning in this regard is that learning is a form of social participation, which is essentially a process in which people actively participate in a community of practice and construct their social identity, as Wenger illustrated in the following figure:(Wenger, 1999)

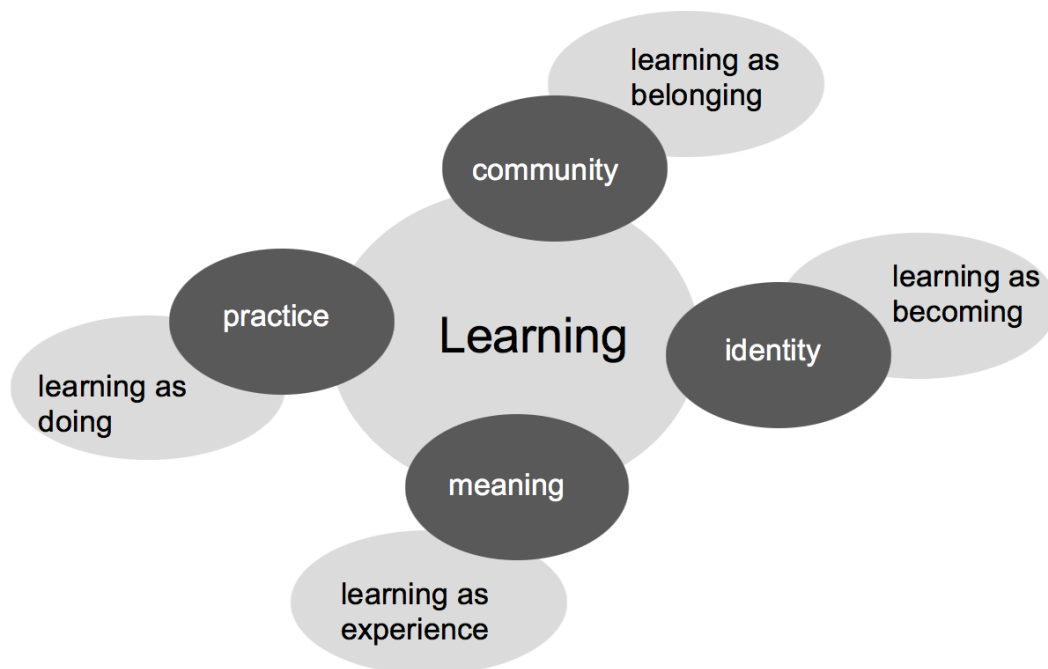


Fig 1.3 Components of learning in Communities of Practice Theory (Wenger, 1999, p.5)

In the above figure, four components of social participation are integrated by learning. They are Meaning, identity, community and practice, as Wenger defines in the following:

“1) Meaning : a way of talking about our (changing) ability - individually and collectively — to experience our life and the world as meaningful.

- 2) Practice: a way of talking about the shared historical and social resources, frameworks, and perspectives that can sustain mutual engagement in action.
- 3) Community: a way of talking about the social configurations in which our enterprises are defined as worth pursuing and our participation is recognizable as competence.
- 4) Identity: a way of talking about how learning changes who we are and creates personal histories of becoming in the context of our communities.”
(Wenger, 1999, p.5)

By proposing the interconnected concepts, Wenger argues that learning is essential to the community of practice. To individuals, learning is the approach for them to be engaged in the communities of practice, while for the community and the organization, learning is use for renewing rules of interaction and accepting new members. Learning is not separate from the other activities of communities of practice, it is embodied in the other activities of community and organization. It is the way we participate and become involved in a community(Wenger, 1999) .

To conclude chapter 1, we have reviewed three waves of collaborative learning research, each with different research focus and method based on their different understanding of what learning is. The cooperative learning perspective majorly focuses on “learning in groups” as a pedagogical method in classrooms. Cooperation is mostly seen as a condition to compare with the individual or competitive condition. The positive inter-dependence theory is one of the most influential motivational theory in the cooperative learning research which explains the better performance of cooperative learning. The socio-cognitive perspective of collaborative learning focus on the process of learning rather than comparing performance. Collaborative learning is seen as a meaning construction process, where interaction plays an essential role. In the socio-cultural perspective, this meaning construction is not isolated, but essentially connected to the social world – the personal historical experience and social cultural context. Learners’ social existence is taken into consideration in this perspective.

The CoLAB is one form of collaborative learning, therefore we inherit many useful result and method in the collaborative learning literature. For example, in categorizing the Co-Meaningfulness, the motivational perspective is critical in understanding the underlying purpose and meaningfulness of the learner. The socio-cognitive perspective focuses on the interaction and co-construction of knowledge which is also a key point in our analysis in chapter 5,6,7. The socio-cultural perspective emphasized the socio-cultural context and its role in the collaborative learning, which we inherit as a starting point of our focused coding in the chapter 8.

At the same time, the CoLAB is also a complex activity that we do not rely on single perspective or theory to study. The purpose of CoLAB is for learners to directly resolving open wicked problems, which brings very distinct challenges and problems that many of the reviewed collaborative learning research does not cover. As CoLAB is a wicked problem, we are inspired by the theories and framework of collaborative learning, but our understanding is generated from grounded theorizing of data directly rather than deduced from the theories.

Chapter 2. Learning Across Boundaries

In the previous Chapter, we reviewed the different perspective researchers take in studying Collaborative Learning. The different perspectives essentially reflect different epistemologies towards the concepts of learning and collaboration. Empiricists regard the learning as a way to process instructed information, while constructivists believe learning is a construction of knowledge from interacting with environment and other people. Social theories of learning study learning in a broader context, where learning is believed to play an essential role in activity and in the community. All the perspectives are important theoretical scope through which we can study the different angel of learning and collaborative learning.

In this Chapter, besides the collaborative learning, we will review the other side of CoLAB learning, which is the “Learning Across Boundaries” (LAB). Learning Across Boundaries has a double meaning. First, the learners are from multiple disciplinary background, which sets up the first boundary they need to cross. Second, CoLAB is not only about traditional scholarly project. In many cases, CoLAB is a Project Based Learning aiming at Open Wicked Problems, e.g. a student entrepreneurship project, or a student-centered workshop. The learner will meet real life problems, solve the problems, create new solutions or even redefine the wicked problem. That will require the leaners’ prior experience and knowledge beyond disciplinary training. In CoLAB today, learners often have different social, cultural and political background, therefore their prior experience and knowledge will differ, e.g. how to understand and frame the problem, how to search knowledge, how to utilize knowledge in solving the problem. These differences based on learners’ prior experience and social existence set up the secondary boundaries for the learners, which they will need to cross in the collaborative learning.

The two boundaries are essentially for the same reason - the open wicked problem, which requires disciplinary and interdisciplinary knowledge as well as knowledge and experience beyond them. The following two sections review different literature concerning learning across the two kinds of the boundaries. The first section of interdisciplinary learning literature mostly concerns the boundary of disciplinary knowledge, while the last section of expansive learning concerns to the second boundary beyond disciplinary knowledge.

2.1 Interdisciplinary Learning

We will in this section review the specific topic of interdisciplinary learning, including its history and current state of art research: what causes it to happen, the current situation and problems, and how researchers deal with them. This literature will help us understand the key challenges of interdisciplinary learning and the efforts that have been made to study and solve them.

Interdisciplinary vs disciplinary.

It is essential to understand the modern discipline culture so as to frame and define interdisciplinarity in our time.

The history of categorizing knowledge can be dated back to ancient Greek philosophers. Research in science and humanities, are categorized by their different purpose, whether to look for reasons for human actions, to make typology of living things, to explore the rules of the physical world. This tradition, with the purpose of ordering human knowledge, has been kept over history and given rise to the modern discipline culture.

Though with a long historical tradition, the modern discipline realm was never static. The humans' research interests have gone through several big shifts along with numerous small ones. In the evolution, emerging new problems and questions, scientific or societal, are the major forces driving the discipline change, demanding new means for new ends. Interdisciplinarity has been a natural way for the discipline innovation: to borrow method from existing other disciplines, to look for knowledge that can be used in other ways, to communicate with other experts for enlightenment, to integrate different discipline knowledge for new problems that seems more complex that one discipline can handle, to expand one promising approach to other fields. Practices of these kinds prevailed in the discipline culture when the new questions and problems are more important than keeping on specializing existing knowledge.(Frodeman et al., 2017)

Harvey Graff, comparative historian who studied over 10 cases of 20th century's interdisciplinary practices, started his analysis of interdisciplinarity with this understanding:

“interdisciplinarity is part of the historical making and ongoing reshaping of modern disciplines. It is inseparable from them, not oppositional to them.”
(Graff, 2015, p.5)

Graff's case studies of different interdisciplines, from the life science to humanities, have strengthened his view of this entanglement. This entanglement makes clear that, the function of interdisciplinarity - to innovate the discipline status quo by providing new and different ways for emerging new problems-, overweighs its form- to "integrate", or to "transcend". The reality of interdisciplinarity exists in this entanglement, which should not be overlooked if any definitions are to be made about interdisciplinarity. (Graff, 2015)

This understanding reveals the disruptive nature of interdisciplinarity. In our time, when interdisciplinary has been widely used, it is ultimately a "revolutionary" power, with emphasis on innovation and creativity in its nature. The role of transitioning is vital to interdisciplinarity and its evaluation, which should not only address the effectiveness of problem solving results, but the effectiveness of proposing new approaches towards new problems.

Multidisciplinary - A weak form of interdisciplinary

Interdisciplinary work, benchmarked by the interaction and integration of different disciplines, is more than the addition of multiple disciplines. There are many multidisciplinary practices under the name of interdisciplinarity which do not satisfy the essence of it. Margaret Boden called some of these practices false, or at best weak form of interdisciplinarity (Boden, 1999).

Multidisciplinarity, as described by OECD, is a "juxtapose" of disciplines, which avoid further interaction or integration (Klein, 2010). A juxtaposition means that the disciplines, intact in their knowledge, organization of knowledge, inherent structure, and cognitive tradition, skip the potential "collision" of disciplinary knowledge, epistemology or value, and present as separate and independent knowledge bodies in front of new problems. One typical example would be a curricular design targeting one topic with a series of lectures from different experts, leaving little space or academic aid for discussion of how to integrate them and innovate for new understanding.

Why these forms of interdisciplinarity are sometimes labeled false? It is partially related to our explanation of the function of interdisciplinarity. Multidisciplinary work make minimum efforts in innovating existing discipline methods towards new problems, sometimes even leaving the work of integrating to outsiders who lack knowledge and academic background. A British study of sustainable city has shown the drawback of such practices: multiple proposals from different disciplinary perspectives, with heterogeneous and even contrasting results, were placed before policy

makers, who find impossible to follow any suggestions if they were to integrate themselves (Evans & Marvin, 2006). The means fail to reach the ends.

It is worth mentioning that claimed interdisciplinary work might turn out to be multidisciplinary, even when it wishes to encourage interaction and integration - it just does not happen. This phenomenon is one big challenge in modern interdisciplinary culture, the reason of which will be explained in the later parts.

Interdisciplinary – Major forms of interdisciplinarity

Real interdisciplinarity demonstrates a motivation in the interaction and integration among disciplines, usually driven by the aim of solving complex research questions/problems. For examples, the question “how learners better learn in contemporary society” needs sociological as well as psychological and biological knowledge, at the same time welcomes design studies from anthropologists and designers through practice-based research. Knowledge from different disciplines are shared and communicated, along with a trend in which people dispute and innovate the methods they use to produce knowledge. Results are evaluated from different perspectives, often by peer review, to allow for a comprehensive discussion of what is really valuable and relevant in the field, and what approaches should be allowed and encouraged in reaching them.

However, the extent to which interaction and integration happen differs from research to research.

Some believe the interaction should only happen at the level of mature disciplinary knowledge/methods, since only well thought and well established disciplinary knowledge/methods are useful, while others share a much looser criterion, believing interdisciplinary discussion should happen from bottom-up. The former, more careful, usually takes a top-down method, while the later, more radical, enjoys a grass-root approach (Klein, 2010).

The “safe” mode (the former mode) usually expands existing (often successful) methods to other disciplines: use of statistics in social sciences, ethnographic methods in design research, etc. The expanding of knowledge/methods does not promise a success, but it relies less on radical innovation of interdisciplinarity, as the knowledge and methods are mature and useful already. Whether the contextualization will be successful depends on many factors, e.g. the flexibility of the original knowledge/methods, the gaps between the disciplines: physics to biology is much easier and more

compatible than physics to music. In most cases, this borrowing and contextualizing does not require close and in-depth collaboration between researchers, if the original knowledge/methods is a good fit. Otherwise, if the contextualization meets fundamental difficulties, the “safe” mode might convert to the “radical” mode (Klein, 2010).

The “radical” mode (the later mode) challenges the status quo of disciplines and focus intensively on the questions and look for new ways rather than borrowing an existing one. Typical sign of this higher level of interdisciplinarity is the joint discussion of the fundamentals in the research – key directions, questions, approaches, variables, models, applications, and ethics, etc. A fusion of disciplines takes place as people mutually grow their understanding of other disciplines. Target research questions/problems as well as the ways to tackle them are constantly challenged and redefined.

One sign of “radical” mode is its openness to new researchers and students. As everyone has knowledge in the interdisciplinary pool that has value in creating new ways of understanding, the process does not exclude immature disciplinary knowledge, instead welcome peer learning and creation. Creativity can be found in both modes. Core interdisciplinary creativity is however more significantly needed in the “radical” mode. In-depth collaboration happens more frequently in the “radical” mode, which demands a high level of mutual understanding, meaning making, synthesizing and creating without losing the coherent research validity.

Different purpose and understanding of the function of interdisciplinarity causes the different models – from multi-disciplinary to interdisciplinary. The CoLAB often falls into the radical side of the spectrum as resolving open wicked problems will need different and distant disciplinary knowledge. In our CoLAB, designers and scientists are the two major communities, and their disciplinary training will construct certain degree of boundaries in their CoLAB practice. Interdisciplinary learning is often needed. The study of interdisciplinary, its history and development, typical challenges such as the “contextualization” we reviewed are important theoretical inspirations in our grounded theory

2.2 Expansive Learning

The study of expansive learning, although not at the center of the mainstream learning sciences, is a significant reference of Learning Across Boundaries. The theory of expansive learning, coined by Engeström in 1987 (Engeström, 1987), inherits the activity theory of learning and knowledge creation from individuals and groups. The main focus of expansive learning transcends the

school scenario where learners are obliged with a predefined task and a defined learning process, and focus on the working and organization learning scenarios where learners have to understand, communicate, and create solutions for emerging unstable problem that might not even exist ever before.

The expansive learning is not only a theory in learning sciences that aims to analyze the process, but also advocate for change as a design methodology. Therefore, much work has been done inside organizations of different kinds, e.g. health care center, hospital, schools, library, etc, in order to analyze, theorize as well as to advocate for change. In this section, we will review the expansive learning as the other side of the reference of Learning Across Boundaries.

The Qualitative Changes in life

In the introduction of expansive learning, Engeström points out that the traditionally highest level of learning – “problem solving”(Gagné, 1965), is still a reactive form of learning(Engeström, 2015). Engeström gives one example of what he believed to fall into the “problem-solving” mode of learning – Donald Norman’s self-analysis of his learning Morse code, in which Norman focuses on words instead of letters and largely improves his speed of learning(Norman, 1982).

Engeström argues that the “problem solving”, even regarded as the most advanced level of cognitive learning, is still safeguarded in a given context with a predefined learning task, as in the case of Norman – the task is to learn a pre-existed input system: the Morse code quickly. This kind of learning, according to Engeström, “is defined so as to exclude the possibility of finding or creating new contexts”(Engeström, 2015, p.2). But this presumption is challenged in today’s social practices, as in many ways, we face situations that requires swift learning to reframe, redefine problems in an emerging context and reinvent solutions for the problem, either by individuals or by communities and organizations. The learning is not safeguarded by predefined context, nor does it has a existed task that we know or we can anticipate. These situations are referred by Engeström as the qualitative changes in life(Engeström, 2015).

The qualitative changes in life immediately brings in his radical argument of the “futility of learning”. Whatever learned in the traditional sense, with a given context and predefined task, may become obsolete under the qualitative change of life, even if it is a complex skill with a long time learning, since the context assumed is changed. Learning is futile for users who accept and learn the designer’s perfectly-designed user-friendly system, but fail to adapt to new

scenarios and new problems. Learning is only meaningful when it enables the users to work out their own plan for the qualitative changes in their own using of the system(Engeström, 2015).

The criticism that Engeström made on the reactive form of learning reflects his emphasize of learner's active role involved in life and production, which posits learner in the role of advocates rather than a passive receiver. This stance, which can find its origin in Hegel and Marx, is more significant in today's fast-changing context.

One of the extreme example of the qualitative change in life Engeström proposed is the "runaway objects" (Engeström, 2009), by which he refer to the significant objects having massive distribution over space and time, such as climate change and pandemic. These are also objects that no single person, community or even single nation can deal with, and they must be seriously confronted by humanity as a whole for our collective future. The extreme example of "runaway objects" presents the qualitative change and requires we all as learners to cross our boundaries to learn for creating solutions. This process of learning transcend the traditional modes of learning, as Engeström presents the following argument:

"The basic argument is that traditional modes of learning deal with tasks in which the contents to be learned are well known ahead of time by those who design, manage and implement various programs of learning. When whole collective activity systems, such as work processes and organizations, need to redefine themselves, traditional modes of learning are not enough. Nobody knows exactly what needs to be learned. The design of the new activity and the acquisition of the knowledge and skills it requires are increasingly intertwined. In expansive learning activity, they merge." (Engeström, 2016, p.39)

Learning Beyond School Scenario

What does expansive learning look like ? Who are the learners? And understand what circumstances do they implement expansive learning ? The following examples casts light to the typical expansive learning scenarios:

"(1) The municipal home care in the City of Helsinki supports elderly people who live at home with various kinds of medical problems. Home care workers visit their clients to dispense medications and conduct various routine chores such as showering, preparing meals, and so on. The home care managers and workers are now struggling to redefine their work and

services so as to meet such demanding problems as increasing loneliness and social exclusion, loss of physical mobility and dementia. The challenge is complicated by the fact that the population of Finland is aging very rapidly and it is increasingly difficult to recruit and retain competent home care workers. How can the managers, workers and clients learn to work in such a way that the new needs are met and the society can afford to provide the service? “ (Engeström, 2016, p.35)

“(2) As journals and books have increasingly become available through the Internet, researchers seldom need to visit university libraries physically. University libraries are becoming automatic mediators of digital information for researchers on the one hand, and physical book repositories or reading halls for students on the other hand. This threatens the professional competencies and jobs of librarians. The managers and workers of the libraries of University of Helsinki are struggling to redefine their work and services on the basis of creating partnerships and flexible practices of collaboration with research groups in need of comprehensive design and maintenance of their information management. How can librarians and research groups learn to operate in such a new way?” (Engeström, 2016, p.35)

The above two examples was used by Engeström to illustrate typical scenarios of expansive learning. The home care managers and workers in Helsinki are no longer students, nor are they novice to the job, yet they are facing increasing challenges in their work. New situations and problems emerge, which require them to swiftly change and solve the problem, as individuals and as a team: they have to learn. The same happens to the university librarians whose job has to evolve as the way people use libraries changes. Learning should happen among themselves and the people and environment that are involved in the new situation.

Learning of this kind happens beyond the traditional school scenario, where students learn under the instruction of teachers, who design and define what they should learn and how they should learn. The learning takes place almost anywhere new “object” is needed to solve or redefine new problems. Engeström’s theory of “expansive learning” is one theory for the untraditional learning scenarios, by which he argues that expansive learning should “transform and create culture”, promote “horizontal hybridization” and form “theoretical knowledge and concept”: (Engeström, 2016)

“Is learning primarily a process that transmits and preserves culture or a process that transforms and creates culture?

Is learning primarily a process of vertical improvement along some uniform scales of competence or horizontal movement, exchange and hybridization between different cultural contexts and standards of competence?

Is learning primarily a process of acquiring and creating empirical knowledge and concepts or a process that leads to the formation of theoretical knowledge and concepts?

The theory of expansive learning puts the primacy on communities as learners, on transformation and creation of culture, on horizontal movement and hybridization and on the formation of theoretical concepts” (Engeström, 2016, p. 36)

In this regard, expansive learning is inherently different. Learning is not seen as the function of preserving culture, it is instead the process through which people reinvent objects, rules, tools, and ultimately culture. In the traditional view of learning, people learn from those who are more experienced and knowledgeable, by which they reinforce the knowledge and culture, and learn what is already there. The expansive learning, on the contrary, is purposed at reinventing what is already there, which ultimately transforms and creates culture by the learning process. The Helsinki home care workers and librarians’ learning is of this kind. They will need to learn to face the new challenge, the precedented solution of which does not exist. (Engeström, 2016)

The horizontal hybridization is more significant than the vertical improvement. For health home workers, since the challenge they face is new, there are no experts from whom they can learn the ready solution. The vertical improvement as in a standard training with predefined criteria does not exist. Learning takes place more often in the horizontal communication among the learners and with the others in the environment, e.g. with the patients and their relatives, other social workers, policy makers, etc. The highlight of horizontal hybridization makes boundary transcending essential to expansive learning. The learners will have to learn from those who have different experience, who share different viewpoints, and who live in different culture. No one is a expert that everyone learns from, and everyone learns from everyone and every object.

Engeström conclude this difference by using a distinct metaphor of learning, which is the metaphor of “expanding”. He disagrees that expansive learning can compare to either “acquisition” and “participation” metaphor, the former of which inherits an empiricist tradition of “knowledge acquire and process”, and the later regards learning as the way to enter and participate in a community(Sfard, 1998). The main argument is that both “acquisition” and “participation” assumes a directional process from the incompetent to become

the competent. But in expansive learning, this directional process is blurred and replaced by a creation process that generate new object and concepts: “In expansive learning, learners learn something that is not yet there. In other words, the learners construct a new object and concept for their collective activity, and implement this new object and concept in practice.” (Engeström, 2016, p.37)

Activity Theory of Expansive Learning

The study of expansive learning has been based on the activity theory, which we reviewed in the chapter 1.4. The activity theory argues that activities is the basic analytical structure of human practice, which is essentially different from the smaller unit of practice of “actions”. The action is individual and short term, such as the a one-time killing in a hunting. But the activity is collective and generic, such as the hunting activity, which consists of multiple actions in the form of divided labor, including chasing, killing, etc. An activity can repeat time and time again and will also evolve as human practice changes for various reasons. (Leont’ev, 1978)

The role of expansive learning is manifested in the evolve of activity. When people face qualitative changes, they will need to change their activity to face the new challenges, either in work or in life. The change can happen in a constant way or a sudden way through the expansive learning activity. From this perspective, Engeström defines expansive learning as an activity-producing activity:

“The essence of [expansive] learning activity is production of objectively, societally new activity structures (including new objects, instruments, etc.) out of actions manifesting the inner contradictions of the preceding form of the activity in question. [Expansive] learning activity is mastery of expansion from actions to a new activity. While traditional schooling is essentially a subject-producing activity and traditional science is essentially an instrument-producing activity, [expansive] learning activity is an activity-producing activity.” (Engeström, 1987, p.125).

The activity theory provides a basic frame for the study of expansive learning, which is an important theoretical reference to the CoLAB.

In our thesis, the CoLAB activity is not studied majorly in working situations, but in universities and schools. Therefore, the specific situation will differ from many of the expansive learning scenario. But the features of expansive

learning that we reviewed very much align with the feature of CoLAB. The qualitative change of life tells the reason and existence of the “open wicked problems”, and the collaboration and boundary-crossing are also very much discussed in the expansive learning. Expansive learning “transform and create culture”, promote “horizontal hybridization” (Engeström, 2016), which is also the ultimate purpose and approach for CoLAB. The difference besides the learning situation lies in the perspective and method we adopt. The expansive learning particularly focuses on the socio-cultural perspective and follows the activity theory. In CoLAB study, we are still interested in the socio-cognitive and the interactionist perspective, therefore we partially inherit the socio-cognitive perspective and use grounded theory to generate our theory as the hybrid perspective theory of CoLAB is very rare. But we are also highly interested in the socio-cultural perspective and get inspired from the expansive learning from it emphasize of “object” and “culture”, which is reflected in our coding of “Project” and “Meaningfulness” especially after chapter 8.

Chapter 3. Qualitative Research Methodology

In this chapter, we will review qualitative research methodology in general. Qualitative research methods is a collection of multiple methods that are widely used in various areas of social research, e.g. anthropology, sociology, psychology, and education research. In this research, we adopt the constructivist qualitative paradigm, we will mainly review the basic epistemological ground of this paradigm, its most prominent features and benefits. With this general understanding, we will explain why constructivist qualitative research methods are used in our thesis.

3.1 The Constructivist Qualitative Research Paradigm

The first questions of qualitative research methods concern the ontological and epistemological lens with which we view the world. In the tradition of qualitative research, there are several different paradigms. Each of them is distinct in viewing the nature of reality and knowledge hence has different methodology. In this section, we will particularly review the constructivist paradigm of the qualitative method, in comparison with the objectivist paradigm and explain why we choose the constructivist paradigm for our research.

The Constructivist Paradigm

Before we review the constructivist paradigm, we would like to mention the objectivist research paradigm which many researchers adopt. The objectivist paradigm emphasizes that the reality exists objectively in the world, and the task of the researchers is to discover it with the right tools and methods when they observe, measure, and prove it. The reality exists whether or not human observes it. The purpose of objectivist qualitative research is to generate reliable knowledge of the social reality that is generalizable to other situations, therefore it is crucial to triangulate findings with different data and methods to make sure the knowledge is accurate no matter who is observing. As the objective knowledge of reality is the main pursuit, human bias in the research process should be minimized. Therefore researchers with this world view will say little on who they are in their research, as the identity and social existence of the researcher should be independent to the knowledge - if there is an influence, it will only undermine the liability of the research. (Tracy, 2019)

The objectivist epistemology is the dominant epistemology in experimental science, where researchers prove or disprove material knowledge with mainly quantitative tools such as statistics. The success of objectivist epistemology

and quantitative methods also influence the science of human and society. In many areas of social sciences, the positivist perspective with quantitative methods pervades (Bhattacharjee, 2012). Qualitative methods can also take objectivist paradigm when the researcher believes his or her role is to discover and prove the objective knowledge of human and society with qualitative tools, such as interviews, qualitative surveys, focus groups, etc. For a more detailed review of qualitative methodology with objectivist paradigm, one can refer to a complete sourcebook written by Miles et al. (Miles et al., 1994)

But there are also fundamental challenges for the objectivist world view, one of which is the inability of human in understanding the complex reality of human and society. For example, post-positivist, which develops from the objectivist paradigm and focuses on the causality and pattern of social reality, accepts that the understanding of researcher of the social reality is inherent partial and biased. The complete and holistic understanding of reality as an object is impossible.

The constructivist world view (or the interpretive world view as some researchers call), however, denies that the reality exists independently to the researcher's activity in engaging in the context of research. On the contrary, the reality is *constructed* through the process of communicating, interacting and understanding. The following metaphor made by Tracy (2019) illustrates the basic world view of the constructivist (or interpretive in the text) perspective:

If you asked an interpretive scholar, "If a tree falls in the woods and there is no one there to hear it, did it really make a sound?" answers would be less clear-cut and more involved than the positivist answer. Interpretive scholars might say that the issue depends on the meaning of the word "sound." Given that sound requires a listener, perhaps the tree did not have sound if no one was listening; or maybe it had a different sound, depending on who or what was present at the scene (a baby, a chipmunk, a researcher, a digital tape-recorder, or a journalist). Also, interpretive researchers might argue that what is classified as having a sound differs from person to person. Does the air conditioner in the background create "sound"? What about the sound of your own breath or heartbeat? Perhaps you are getting bored or hungry or agitated; do any of these states have sounds? Interpretivists would ask and gain insight from multiple points of view, from multiple participants, and from themselves, to answer the question. (Tracy, 2019, pp. 40-41)

In the above explanation, the researcher's purpose and understanding is essential in constructing even the question itself, not to mention the

knowledge constructed. In this regard, the researcher cannot be isolated from the knowledge of reality. It is in the exact process of empathizing, understanding and interpreting, when researchers construct the interpretive knowledge of the social actors' action, thoughts and their social and cultural context. Therefore the reality does not exist as an absolute object. The researcher's social and political existence, viewpoints, purpose and interests will inevitably be included in the construction of reality.

In contrast to the objectivist viewpoint, the inclusion of researcher is not seen as lack of liability, it is instead an essential part of the interpretation. The ultimate rationale for taking this epistemology is the ontology of reality in the constructive world view. The reality is not material to be measured, but socially constructed for reading and interpreting. The constructed reality is first lived by social actors and then understood, interpreted by the researcher.(Tracy, 2019)

In the following table(Table 3.1), Marvasti listed the theoretical stance and the goal of research respectively in the positivist and interpretive paradigm (Marvasti, 2004, p.8).

	Objectivist	Constructivist
Theoretical stance on social reality	How can we use objective research methods to capture the essence of social reality?	How is reality socially constructed ?
Goal of research	What are the universal laws that explain the causes of human behavior?	How do situational and cultural variations shape reality ?

Table. 3.1 Points and emphasis of objectivist and constructive world view. (adapted from (Marvasti, 2004, p.8))

In this thesis, we will adopt a constructivist framework. The detailed rationale of adopting this framework will be elaborated in Chapter 3.2. But at this stage, to make explicit comparison between objectivist and constructivist ontology and epistemology is important. The pragmatic reason of the comparison concerns the purposes of this research, one of which is to illuminate educators who are promoting interdisciplinary learning or collaborative learning across boundaries etc. In many of these initiatives, educators are not necessarily social scientists familiar with the constructivist paradigm. Normally, if the educator receives training from experimental science, he or she might assume an objectivist perspective. As the concept and knowledge in this thesis is constructed rather than objectively measured or proved, we need to present the theoretical and paradigm ground, which is inherently related to the constructivist framework of qualitative research method.

Besides the two world views we review, there are also critical theory and post-modern world views that are widely adopted in qualitative research. Although some theories of learning that we reference (e.g. expansive learning) have close connection to these paradigms, we do not rely on their methodology in this thesis. Therefore we do not particularly review critical theory and post-modern epistemology here, and interested readers can refer to comprehensive handbooks of qualitative research, e.g. (Denzin & Lincoln, 2011), for further detail.

Features of Qualitative Research Under the Constructivist

Paradigm

What does constructivist (or interpretive) qualitative research look like? Merriam summarized four essential features of constructivist (or interpretive) qualitative research, which are 1. Deep understanding 2. Researcher as Research Instruments 3. Inductive 4. Richly Descriptive (Merriam, 2002).

● Deep understanding

The essential feature of constructivist (or interpretive) qualitative methods, or qualitative methods in general is to obtain deep understanding of the target phenomenon. Unlike quantitative inquiry which measures the social reality with numbers, qualitative research very often focuses on the “why” and “how” questions, the answer of which can hardly be measured. Therefore, deep understanding of the social actor, their situated actions, as well as the cultural context become the premise of qualitative research. For example, one can measure the degree of even the most detailed actions of students in a classroom with numbers, but qualitative research concerns questions such as why they conduct such actions, what is the meaning behind it, and how teacher-student interaction influence such actions, etc. In the interpretive qualitative research perspective, these questions concerns symbolic meaning constructed through communication and interaction of the social actors, that can be understood by the researchers with another interaction between the researchers and the students, such as in-depth interview and observation, etc. (Blumer, 1986)

Qualitative researchers intend to obtain deep understanding of the social phenomenon. With this purpose, researchers adopt methods such as in-depth interview and participant observation, etc. For example, the in-depth interviews are often in the form of semi-structured interview, where the researcher not only ask prepare questions about certain issue, but also interact with the interviewee when they feel it is necessary for the interviewee to explain in great detail and reflect on the issue. Participant observation

allows researchers to get immersed with the natural setting of people and context, providing a close enough perspective for the researcher to understand deeply. For example, in this thesis, the author works and lives with the other CoLAB organizers, therefore can obtain deep understanding through close interaction with them (refer to chapter 5 for more details). These methods can be used together to get a deeper understanding of the phenomenon.

● **Researcher as Research Instrument**

The second feature of qualitative research methodology is that the researchers are themselves the instruments for research activities, e.g. sampling and collecting data, analyzing data, etc.

The quantitative research instruments are often objects: experiment instruments, quantitative surveys, physiological measurement instruments, etc. They are useful in collecting and analyzing objective data. But in qualitative methods, especially the interpretive qualitative methods, the researcher himself is the key instrument. The researchers develop their knowledge of the target phenomenon as they research. Therefore, they will respond to the situation, adapt himself of herself to collect and analyze the data with insights. The researcher's own understanding and the involving role is not seen as detrimental to the objectivity. Instead, knowledge is constructed with the researcher's subjective understanding.

● **Inductive Theory**

Interpretive qualitative research starts with the interests in the phenomenon and very often does not require a theory to deduct hypothesis for testing. Instead, understanding is generated through research process, where inductive theory and hypothesis forms iteratively. This inductive intention is also a result of the interpretive epistemology that emphasize the construction of knowledge, which is by itself an inductive process. In this thesis, we mainly adopt a constructive grounded theory method, which has a strong preference in induction. The data is closely examined by the researcher with detailed coding and then categories and concepts are generated from the iterative coding. The theories then stay closely with the data, so that it is an inherent match.

● **Richly Descriptive**

In quantitative research, numbers are most significant representative of the phenomenon. But in qualitative research, one can expect a rich description of the phenomenon, which means that data is presented primarily with forms of text, pictures that are richly descriptive. Researchers will use fieldnotes, memo, transcriptions, documents excerpts, ethnographies, and autoethnographies, etc. to describe the situation.

3.2 Research Methodology Rationale

In this section, we will explain the rationale for choosing the constructivist paradigm and the qualitative methods.

The researcher's world view from facilitating collaboration across boundaries

The world view of the researchers ultimately determines the world view they choose for their research. We will explain how the researcher's constructivist world view gained through his practice is eligible and suitable for this practiced-based research.

I started my bachelor's in physics, and continued my master study in interaction design, in which I worked extensively with artists and designers. In my Ph.D study, these two backgrounds merge for my thesis topic – to study the collaborative learning across boundaries, exemplified by the science design collaboration. The research adventure is however not a conventional social science study, but heavily practice based. I participate in the organization of CoLAB activities and observe and study it at the same time.

In most of my practice during Ph.D, I worked to facilitate the collaboration between different background students to help them learn across boundaries. The mixed background ultimately questions me where the reality resides. In order to help them, I must understand deeply their distinct perspectives. In addition, I also must deeply emphasize with them in what they believe and how they come to believe it, which ultimately concerns their different ontologies and epistemologies. I have to understand and emphasize with the artists' way of expressing, as well as the scientists persist of "truth", their different facets of "reality" and "knowledge", explicit or tacit. To facilitate the fusion, I need to keep constant conversation and interaction with different people and appreciate their respective "reality" but not "choose a side".

This fusionist work is very difficult when I hold an objectivist world view. I might just be too obsessed with the "objective" reality and the ways to get there, hence fail to "grasp" the other realities. The truth is, during the practice, even a objectivist perspective from a social scientist might be seen as too subjective to a "hard-core" natural scientist, not to mention artists and designers. The different world views exhibit already so much clashing, that the collaboration facilitator must introduce a certain degree of relativism and

pragmatism to distract the clashing of where “reality” resides. The constructivist world view is more useful and suitable in this regard. When recognizing reality is socially constructed in different situation and culture and by different individuals, one faces much less obstacle in utilizing and integrating knowledge wherever it comes from, whether from rigid scientific experiments or from artistic introspection.

One might also argue the possibility of implementing practice based on a constructivist perspective and then convert to an objectivist paradigm when analyzing. But we argue it will create more trouble than benefits. First, it will inevitably lose the constructivist thinking generated in the practice. The objectivist perspective will require the researcher to be as neutral as possible so that his or her subjective thinking will not interfere the analysis. But in this case, the perspective of myself as both the facilitator and observer is lost. What I constructed as the reality in the collaboration from the perspective of someone who understands and emphasizes with different backgrounds is no longer important in the analyzing. The emphasis will shift to what are objectively measured and analyzed. Second, it will create discrepancies between data and theory, as the data is collected during participant observation when I facilitate the collaboration with a constructivist world view. The final result will still have the weakness of lacking objectivity although we take a positivist perspective in analyzing, because the data collection is flawed in the objectivist view.

In conclusion, I acknowledge that one can be an objectivist social scientist who build fine objective models and theories for collaborative learning cross boundaries. But in my situation, it is different. I am both a practitioner to facilitate the CoLAB and a social researcher curious on how to improve the collaboration. Therefore, my own constructed reality is part of the whole research. I recognize that the lack of objectivity will be challenged as one of the weakness, as with many researches taking a constructivist point of view. But I also hold that it is important to contribute my insider/practitioner/fusionist “constructed reality” in understanding of the CoLAB phenomenon in addition to the other positivist studies.

Learning from the Constructivist Perspective

The second rationale for a constructivist perspective relates to the historical paradigms of learning. The positivist paradigm regards knowledge as objective for researcher to acquire by measuring and proving. This world view also has its roots in understanding what learning is, which is closely related to the acquisition metaphor of learning(Sfard, 1998). The phenomenon of Collaborative Learning Across Boundaries has a different pattern to the

acquisition metaphor. It is bonded with a constructivist (or co-constructivist) view of learning (Reusser, 2001). In CoLAB, knowledge is mostly not acquired but constructed/co-constructed. Learning happens in the meantime when learners collectively make their prototype and communicate on the different understanding of the project. There is little concrete form of learning fitting the acquisition metaphor, with a clear direction from the unlearned to the learned.

Another phenomenon featuring the constructivism in CoLAB is that learners learn through solving Open Wicked problems, which are themselves so complex and entangled, such as the Sustainable Development Problems (see chapter 1.2 for more explanation on Open Wicked Problems). As the problem is so complex and difficult, everyone is more or less on the same position in term of being knowledgeable of the issue, but everyone also has the potential to contribute their knowledge to the open wicked problem in the co-construction of their joint project. The challenge encourages the group to follow a pattern that favors constructing knowledge rather than teaching and acquiring.

We argue that the constructivist qualitative method is suitable for studying CoLAB learning based on a (co-)constructivist model.

The constructivist qualitative methods give the researcher a consistent epistemological tool for both the phenomenon per se and the process to understand the phenomenon. One will need this consistence for in-depth understanding. For example, I have encountered a situation where a creativity researcher got asked a question, right after his presentation, about whether he think creativity researchers master the key to be creative themselves. The researcher answered, surprisingly quickly and decisively, that they do not. As their method based on neuroscience does not allow them to be creative themselves like their research targets. The anecdote explains the dilemma when the method for researching a phenomenon mismatches the phenomenon itself. The result is still useful, but there will be a lack of in-depth understanding. In the creativity research, it is a great challenge to find a widely accepted scientific method that can also fit the creativity phenomenon. But in our case, the constructivist paradigm is a good fit for both the phenomenon and the study. For example, the Constructivist Grounded Theory reviewed in the following chapter is one widely accepted method for our purpose.

Chapter 4. Constructivist Grounded Theory (C-GT)

In addition to the qualitative research methods reviewed in the previous chapter, we adopt the constructive grounded theory in this thesis as our primary method. The constructive grounded theory is one of the research tools under the interpretive or constructivist qualitative framework. The grounded theory has become a very successful method since Barney Glaser and Anselm Strauss invented it in the 1960s in their three books introducing both the grounded theory and their study of “dying” with this method (Barney Glaser & Strauss, 1966) (Barney G. Glaser & Strauss, 1967) (B. G. Glaser & Strauss, 1968).

Since then, many qualitative researchers have been developing grounded theory based on different epistemology frameworks and research purposes. In this thesis, we will mainly adopt the constructivist version of Grounded Theory developed by Charmaz (Charmaz, 2006). The main difference between Constructivist Grounded Theory (C-GT) and other versions lies in the constructivist premise it takes data collection and analysis is not objective as objectivist researchers would argue but constructed with the researchers’ social existence taken into consideration. The C-GT aligns with our choice of the constructivist paradigm in this thesis.

4.1 Grounded Theory

Grounded theory, from its coinage since the 1960s, has been a successful qualitative tool for many social science researcher and students. Its wide use also expands from the sociology study to many areas of research. Although the most prominent feature of grounded theory is the systematic data collection and analysis methods, grounded theory is more than just a set of methods with guided procedures. We would like in this section to review the origin of this method, its purpose and epistemology, before we enter the detail methods in the following sections.

Generating Theory versus Verifying Theory

When Glaser and Strauss first invented the grounded theory in the 1960s, they emphasize that generating theory instead of verifying theory is their most significant purpose for grounded theory (Barney G. Glaser & Strauss, 1967). To understand this purpose, we will briefly review the historical reason for this need.

The first historical background is gap between data and theory at that time. Glaser and Strauss(1967) made the example of Herbert Blumer's critique (Blumer et al., 1949) on Thomas and Znaniecki's monograph, *The Polish Peasant in Poland and America*(Thomas & Znaniecki, 1918). Blumer's major critique concerns the gap between the data and theory of the monograph, that theoretical conceptions were not grounded on the data, and that the data cannot adequately test the theory they used. This concern aligns with the then trend to better verify theories with better (quantitative) measurement thus better data(Barney G. Glaser & Strauss, 1967).

But Glaser and Strauss(1967) argued that the concern should be reversed:

"What might have happened if Blumer had focused less on the problem of verification and more on generation. He did, of course, come close to emphasizing the latter, since he raised the issue of how to theorize from data rather than from the armchair. But, as we see it, whatever his intent, Blumer threw the weight of his analysis toward an examination of verification, rather than toward the question of bow to generate grounded theory. He left that latter problem largely untouched, apparently assuming that the most one could say was that good theory is produced by a fortunate combination - an inquiring mind, rich experience, and stimulating data." (p. 14)

Glaser and Strauss's focus is clear: we should consider the other direction in filling the gap between data and theory: not just to verify theories with data but to generate theories from data. This created a need for a suitable method in generating theories, especially from data that is highly grounded such as ethnographic observation.

Grounded theory method is built based on this historical background, with the purpose to directly generate theory from data in a systematic way. It proposed an alternative to the then sociology focus – to test the "grand theories" that are logic-deduced. As Glaser and Strauss(1967) pointed out, the difficulty of testing grand theories lies in the fact that these grand theories are generated by the "great men" (Weber, Dirkheim, Simmel, Marx, etc.) through logic deduction and that it is difficult to significantly question these theories as a whole or get deep insights on how they are generated. As a result, the task for researchers is testing these grand theories in various situations with different data, making minor modifications but not generating their own theories or even understanding how to generate theories from data.

Problems emerge as Glaser and Strauss(1967) suggested these grand theories were not enough for covering the every aspect of social life, especially those with new context that the "great men" have not lived

through. There are also problems in understanding grand theories in specific situation. Because the grand theories are not grounded, they might not be easily understandable when applied to the specific situation and context. And finally, Glaser and Strauss(1967) claimed that it does not require a “great men” or “genius” to generate a theory. Sociology theory can be generated and understood by students and by “significant” laymen. But to achieve that goal, we will need a systematic method to help us generate theory from data, which is the later proposed grounded theory method that has been successful for the past decades.

To conclude, the rationale for grounded theory resides in the following arguments that concern generating grounded theory.

1. Grand theory has gaps from data, verification sometimes does not work
2. Grand theory cannot reach every aspect of life, especially in emerging phenomenon.
3. Generating grounded theory is one way to fill the gap.
4. We should learn to generate with systematic methods
5. Everyone, not necessarily genius, can learn to generate theory from data.

Pragmatism and Grounded Theory Method

Before we go into the detail of grounded theory method in the next section, we would like review the relation between pragmatism and grounded theory, that cast lights to the further purpose of Grounded theory.

In a pragmatism perspective, theory is for the purpose of facilitating action or increasing understanding(James, 1907). As Glaser and Strauss argued, the ultimate position for the grounded theory is that it serves as “a way of arriving at theory suited to its supposed uses” (Barney G. Glaser & Strauss, 1967, p.3). What is the “supposed use” then? Glaser and Strauss further gave their definition:

- (1) to enable prediction and explanation of behavior;
- (2) to be useful in theoretical advance in sociology;
- (3) to be usable in practical applications-prediction and explanation should be able to give the practitioner understanding and some control of situations;
- (4) to provide a perspective on behavior-a stance to be taken toward data; and
- (5) to guide and provide a style for research on particular areas of behavior. (Barney G. Glaser & Strauss, 1967, p.3)

There is a strong sense of “usefulness” in the above definition especially the in (3)(4). This purpose is obvious when they claim grounded theory “fits empirical situations, and is understandable to sociologists and layman alike.”(Barney G. Glaser & Strauss, 1967, p.1). Grounded theory should be understandable to sociologists as well as layman alike – who, as important practitioner readers, will make significant practical use of the theory. This practical use is sometimes hard for the all-inclusive grand theories that appear formidable to layman.

In the later development of grounded theory, there are divergence towards either an objectivist(Barney G. Glaser, 1992) or a constructivist(Charmaz, 2006) direction. The difference clearly resides in researchers’ epistemology choice as we have reviewed in the Chapter 6.1. But the close relation with pragmatism provides epistemological ground for both paradigms.

Antony Bryant(2017) explained how pragmatism can set up the criteria for generating ground theory without falling into the dichotomy of objectivist and constructivist paradigm:

From the perspective of Pragmatism, the issue of the relationship between theory and practice is one of how useful the former is with regard to the latter; theories are judged in terms of their utility, as examples of “enacted truth.” If a new theory has no impact on existing practices, then we are in the realm of Dewey’s difference principle, which states that any dispute between proponents of the old theory and the new one is not of any practical concern, although it may be that these differences do prove to be important at a later time. New theoretical insights, whether in the form of grand theories, conceptual models, or some such, need to be judged in terms of the differences they make to people’s practical understanding and actions. Strauss’s continuing interest in theories of action and interaction in social settings provided evidence of this need. (Bryant, 2017, p.343)

The purpose of grounded theory has a strong bond with the pragmatic philosophy tradition. Theories are judged by their utility, which will need to improve people’s understanding of practical actions. This purpose is also significant in our thesis, as we will constant mention in our analysis in the later PARTs.

In addition to the purpose, the grounded theory has an inherent strong relation with the pragmatism in terms of the understanding of data, coding, theory as process, and iterative inquiry, which are discussed in detail in (Strübing, 2007). As here we would like to focus on the purpose of grounded theory with

a pragmatism perspective, interested readers can refer to Strübing's paper for further discussion.

To conclude, grounded theory is a set of systematic methods that Glaser and Strauss developed to generate theory directly from data. It was proposed as an alternative to test deduced hypotheses from existing (grand) theories. Glaser and Strauss explained the rationale was to fill the gap between theory and data and to allow more new theories from not only "genius" but also students and "significant layman". The grounded theory generated in this way has an inherent link with data and the substantial context (as in Glaser and Strauss's case the study of dying and death of serious ill patients), hence they are mostly substantial theories (Bryant, 2017). The pragmatic purpose for grounded theory is emphasized so that the theories are used to provide new understanding, perspective and guidance to the practice.

4.2 Constructivist Grounded Theory (C-GT) Method

The canonical grounded theory and its development especially by Glaser is based on objectivist or positivist assumption. In the 2000s, Charmaz and others developed the grounded theory based on the interpretive or constructivist epistemology (Charmaz, 2006). The constructivist grounded theory (G-GT) holds that both the data and analysis is socially constructed by the researcher rather than objective, as the researcher is part of the world they study. In the objectivist grounded theory, data is independent of researcher and the aim is to generate context-free generalization of the grounded theory. While in the constructivist grounded theory, observation and analysis are socially constructed and the aim is to create reliable, original and useful theory.

In this section, we will introduce in detail the constructive grounded method, its specific method and rationale.

The C-GT is an offspring of grounded theory in general, therefore it inherits the general principles and purpose of Grounded theory, which is to generate theory from grounded data through a systematic method. The method is characterized by a systematic, iterative and flexible use of different strategies of coding, categorizing, Memo-writing, conceptualizing, sampling and theorizing. Charmaz (2006) summarized the defining components of the systematic methods as follows:

- "Simultaneous involvement in data collection and analysis.
- Constructing analytic codes and categories from data, not from preconceived logically deduced hypotheses

- Using the constant comparative method, which involves making comparisons during each stage of the analysis
 - Advancing theory development during each step of data collection and analysis
 - Memo-writing to elaborate categories, specify their properties, define relationships between categories, and identify gaps
 - Sampling aimed toward theory construction, not for population representativeness
 - Conducting the literature review after developing an independent analysis.”
- (pp. 5-6)

The above components presents a few key understanding for the grounded theory.

First, there is a strong dependence on the data. All the components more or less emphasize this understanding, as data needs to be simultaneously involved, compared to generate codes, categories that ultimately to advance the theory.

Second, there is less dependence on preconceived concepts, theories or hypotheses. This aligns with the purpose of generating theories instead of testing deduced hypothesis. Charmaz emphasized that the codes and categories need to be constructed from data not from preconceived theories and that literature review should come after developing the analysis, which precludes the dependence of preconceptions when analyzing.

Third, it is a developing and iterating process. The theory generating is a constant and iterative efforts, it is manifested in abstracting the codes and categories, in comparing different data, codes, and categories, in self-reflexive process such as memo-writing, and in further sampling to advance the theory. The advancing from data to codes, then categories, concepts and eventually to theories is a continuous yet iterative abstraction.

The different components construct the whole grounded theory methodology, which we will review in detail in the next sections. For Charmaz, most of these components of the method align with the canonical grounded theory despite their epistemological difference. Instead of seeing these components as a concrete method process that one should follow in strict sequence, Charmaz regards them as “a set of principles and practices” that one can follow in their own grounded theory(Charmaz, 2006).

Initial Coding

The purpose for C-GT is to generate theories from data in a systematic way. Coding is the first analytic tool researchers use in grounded theory. Charmaz defines coding in C-GT as categorizing “the segments of data with a short name that simultaneously summarizes and accounts for each piece of data” (Charmaz, 2006, p.43). Coding at least consists of two stages: 1. Initial Coding 2. Focused Coding. Initial coding allows researchers to closely scrutinize data, word by word, line by line or incidence by incidence, to define what is happening in the data. Focused Coding means researchers select the most salient and significant codes emerging from the initial codes and test them with more data for further comparative analysis.

The initial coding helps the researcher to abstract actions, relations, key objects, conflicts, meanings and feelings in the data. The generated initial codes are the first analytical abstraction which should stick closely with the data so that the gap between theory and data is small. Once the initial abstraction is made, the codes represent the researchers' selection and segmentation of data that has analytical potential. The set of initial codes can help the researcher emerge the meaningful components in the huge amount of data.

It is important to note that in grounded theory, especially constructivist grounded theory, codes are determined by the researcher from the constructive interaction between the researcher and the data, not determined by preconceived theories or concepts that the researcher passively follows. This approach is typically different from coding in a positivist paradigm in which a logic-deduced framework is present before coding. Initial coding in C-GT does not rely on such a guiding framework or rationale. Instead, the rationale and framework is *to generate from* the initial coding, not for the initial coding, which exemplifies a highly abduction-based rather than deduction-based process. In this process, two key points are essential: first, the true analytical value is driven by data and its meaning construction rather than driven by theory-testing; second, initial coding encourages generative coding so that one can identify important analytical insight for new areas that the research might not be aware of before scrutinizing data.

We use the following initial coding (Table 4.1) taken from Charmaz (2006) to exemplify what initial coding is:

Receiving second-hand news Being left out; Accusing mother of repeated not telling; (questioning ethical stance?) Being confronted Facing self and identity questions; Demanding self-disclosure and information Experiencing escalating pain Expecting to manage pain Inability to control pain Rapid worsening of pain Having excruciating pain Becoming frightened; Foreseeing breathing crisis Breaking the news; Informing daughter of plan Explaining projected treatment Having access for making contact Leaving follow-up contact open-ended No follow-up Ascertaining the time between contacts Explaining lack of disclosure Accusing daughter of not caring Expressing hurt; Assuming lack of caring; Making negative inferences (of a moral lapse?) Accounting for not telling Sounding fine Questioning daughter's expectations Explaining need for emotional control Seeing life-threatening risk of losing control Teaching that mode of telling does not reflect state of being Sounding like a 'normal' mom	She found out from Linda that I was, had been in bed for days and she called me up, 'You never tell me, and I have to find out from Linda,' and 'Why don't you tell me who you are and what's going on and ...' Well, I don't know how long after that, but that Saturday the pain started right here and it, throughout the day it got worse and worse and worse. And she—I kept thinking that, well, I can deal with this, so I took some kind of a pain pill and nothing helped. And that was about one in the afternoon. Well, it got worse and worse so that every time I took a breath the pain was horrible, so by seven, eight o'clock that night, I was scared because I knew that if it got any worse I wasn't going to be able to breathe. So I called her and then I told her what was going on, that I was going to be driven to the doctor because they were going to try giving me shots of zyllocain or something to try to locate a point to where maybe it would go in there and numb the pain for me so that I could breathe. Well, I called her and told her this. And I have a car phone. She says, 'Well, Mom I'll call you later or you call me.' Well, I didn't call her; she didn't call me. That was Saturday night. She didn't call me until—she called me about noon on Monday, and I finally said, 'Well look, this is why I don't tell you, because when I told you Saturday night, you never called, you didn't care or anything and it really hurt my feelings. So that's why I don't tell you when I have this going on.' And she said to me, 'Well, Mom, you sounded perfectly fine.' And I said, 'Well, what do you expect me to do, become an emotional wreck or something?' I said, 'I have to keep everything still and quiet in me in order to control, because if I went into emotional frenzy, I would have not been able to breathe,' you know. So she started really trying to understand that just because I was scared to death, I was in horrible pain, but when I called her, I guess I was just a normal mom.

Table 4.1 Charmaz (2006) initial coding on the interview of Bonnie (p. 52)

In this interview, the interviewee Bonnie who lives alone suffers from a chronic illness (systemic lupus erythematosus) that developed quite serious during the past year. In the interview, Bonnie explained how it was difficult to communicate to her daughter about the illness even when it is life-threatening.

The initial coding from Charmaz took a line-by-line fashion. Charmaz scrutinized the data line by line and developed her understanding for abstracting the key elements of the story. The codes consist multiple

dimensions of actions, feelings, rationales and consequences. The initial codes do not follow a strict preconceived guide, but is instead used for generating analytical categories from the abstraction. The codes are not final, with some following a preliminary format (e.g. “sounding fine”, “a moral lapse?”), which are acceptable as they serve as the intermediate product in the process of iterative generating. The main use of initial codes is for the researcher to really immerse themselves in the data, to read through and compare, and to extract key categories. The language for the codes is also essential as it represent the analytical thinking of the researcher.

The initial codes together as a whole presents how Charmaz extracts for the story, which is centered on “telling” and “self” as Charmaz (2006) further reflects:

Her story shows how telling news can be fraught with problems. Misunderstandings and dilemmas arise. Hesitancies occur. Accusations ensue. Explanations follow. Telling the news can open the self to view, risk emotional costs, and force questions about relationships. Not telling or delayed telling can also rent or rupture bonds. Familial failures, ethical slights, and moral claims accrue, from one or another person's view. (p. 45)

By initial coding, Charmaz was able to extract a set of codes that she interprets as essential in Bonnie’s story. The codes were generated from close reading of the data by the researcher which defines the space available for the next analysis.

Focused Coding and Categories

Focused coding is the second phase of coding in C-GT. Charmaz(2006) defines focused coding as a process to “use most significant and/or frequent earlier codes to sift through large amounts of data. Focused coding requires decisions about which initial codes make the most analytic sense to categorize your data incisively and completely.” (p.57)

In focused coding, two important steps are essential: 1. to select the most salient and/or significant codes from initial coding. 2. to test the code with larger data for further analysis.

If the initial coding is a divergent phase which opens our analytical space, the focused coding is a convergence phase which concentrates the analysis for fine-tuning. As we see from the above example of Bonnie’s story (see table

4.2), although Charmaz made the first abstraction, the whole set of codes still remain very open. We will need one or several pivotal codes to construct the categories or framework with which we can sort and organize the codes into analytic use. Focused coding serves this purpose.

Like initial coding, in C-GT, focused coding is a constructive process. Choosing the salient and significant codes is both grounded in understanding the data and in the researchers own meaning making. Sometimes, the process is iterative, researchers might not be able to locate the most significant codes at first sight, he or she may need to continuously interact with the data, try to test different analytical directions and finally come to the focused codes that has the most analytical potential. Sometimes, new ideas emerge as the researcher iteratively review the codes and data so that he or she might continuously evolve the analytical direction while converging. The converging and selecting is constant comparing process, researcher compare different codes with data, data with data, codes with codes to see their relationship, dependence and generalization. A good focused code is pivotal to different other codes and has the potential to be applied to more data.

In the following example (Table 4.2), Charmaz (2006) made such focused coding “avoiding disclosure”, “managing emotions”, “assessing potential loss and risks of disclosing”, etc. These codes are one step further to the initial codes that present key actions and feelings that is central to their chronic illness experience.

Avoiding disclosure	Excerpt 1 <i>Christine Danforth, age 37, lupus erythematosus, Sjögren's syndrome, back injuries</i> If you have lupus, I mean one day it's my liver; one day it's my joints; one day it's my head, and it's like people really think you're a hypochondriac if you keep complaining about different ailments ... It's like you don't want to say anything because people are going to start thinking, you know, 'God, don't go near her, all she is—is complaining about this.' And I think that's why I never say anything because I feel like everything I have is related one way or another to the lupus but most of the people don't know I have lupus, and even those that do are not going to believe that ten different ailments are the same thing. And I don't want anybody saying, you know, [that] they don't want to come around me because I complain.
Assessing potential losses and risks of disclosing	Excerpt 2 <i>Joyce Marshall, age 60, minor heart condition, recent small CVA (stroke)</i> I have to see it [her CVA] as a warning. I can't let myself get so anxious. I have to live one day at a time. I've been so worried about John [her husband who had had life-threatening heart attacks and lost his job three years before retirement] and preparing to get a job [her first in 38 years] ... It's just so hard with all this stress ... to concentrate on what I can do today. I always used to look to the future. I can't now; it upsets me too much. I have to live one day at a time now or else there may not be any me.
Feeling forced to live one day at a time	
Concentrating on today Giving up future orientation	
Managing emotions Reducing life-threatening risk	

Table 4.2 Charmaz (2006) focused coding (p.58)

With a further review, one can find two of focused codes, namely “avoiding disclosure” and “assessing potential loss and risks of disclosing”, have connection to the code “demand self-disclosure” in the previous interview with Bonnie (Table 4.1), which illuminate the researcher to focus on the action of “disclosure” and “self-disclosure” for further analysis – what is the different situations in the “disclosure” action, why they are different and how, etc. Focused codes like “disclosure” can develop into “**categories**”, which means they apply to different data and illuminate further comparative analysis – to generate more sub-categories based on the categories, to fit in more data and

codes to the category, to develop more properties to the category, or to understand the relationship between one category to other categories.

Categories are essential to grounded theory, as they construct an analytical cluster for the initial codes that represent a significant action, process, feeling and objects. Confirming categories is an iterative process, as one will need to test this category with new data, which possibly evolve the existing category. The evolve also includes developing new sub-categories and properties for the category.. For example, a “disclosure” of illness can have sub-categories as “self-disclosure” or “other-disclosure”, and properties like “calm”, “painful”, “reluctant”, etc. based on different data and how the researcher define the data. Once the category is confirmed, the research will need to test it with extensive data to develop a complete set of sub-categories and properties for the substantial field. This process to sample for complementary data is called “theoretical sampling”(Barney G. Glaser & Strauss, 1967).

Generating Theory, Grounded Theory and Concepts

The final step of C-GT is to generate theory from the first two steps of coding. The grounded theory generalizing requires the researcher to analyze in-depth the relationships between different emerging categories towards a theoretical direction. Ultimately, the categories are not just for clustering, the grounded theory must introduce a final analytical abstraction to define the relationship between categories, their sub-categories and properties. In other words, the categories can be left as isolated labels for different actions, feelings, objects, consequences, they have to construct an analytical story with dynamic relationships between the categories to explain the substantial field in which we study.

The following figure (Fig. 4.1) illustrates the level of abstraction that pinpoints the relation between categories.

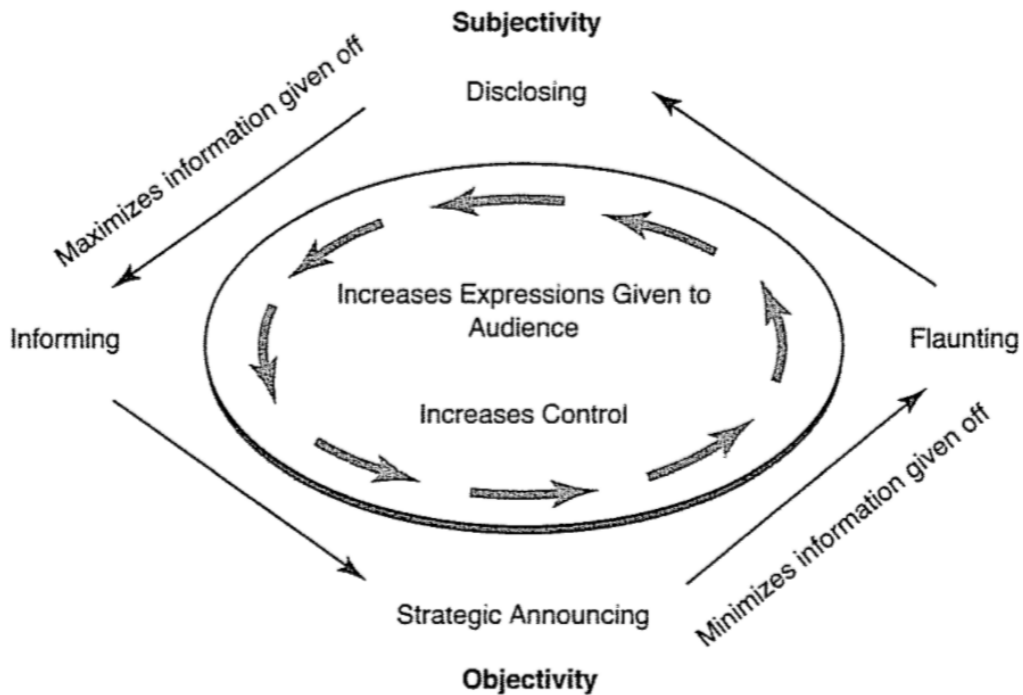


Fig. 4.1 Charmaz's (2006) categories and their relation map on telling chronic illness(p.62).

The different strategies of telling chronic illness is a result of different levels of control in the telling. They can convert to each other when conditions change. The final grounded theory is a further analysis based on the relation map researcher builds, e.g. explaining what conditions trigger the conversion of ways of telling.

Sometimes, researchers consciously guide their theoretical construction with words such as "context", "condition", "cause", "self-other", etc. These words help the researcher to think in the theoretical direction while they try to generate theory from the categories. These words are called "theoretical codes"(B. G. Glaser & Strauss, 1968). In other occasions, researchers might not be aware of the theoretical codes they use in developing their final theory, as in Charmaz's case, she reflects her theory was influenced by the symbolic interactionism without deliberately stating it(Charmaz, 2006).

In developing the final theory, one or two core categories might emerge that pivots the relationship between the categories. These categories are sometimes indicated as **Concepts**. Therefore the final theoretical abstraction can be accomplished by a conceptualizing process.

In the following figure(Fig. 4.2), Bryant explained and illustrated the whole grounded theory with "a spiral abstraction"(Bryant, 2017, p.97). The process features increasing levels of abstraction from data to codes to categories and

to the final concepts. Throughout the process, the researcher will need to constant compare different data, codes and categories, and determine the significance and relation between them, which ultimately constructs the theory.

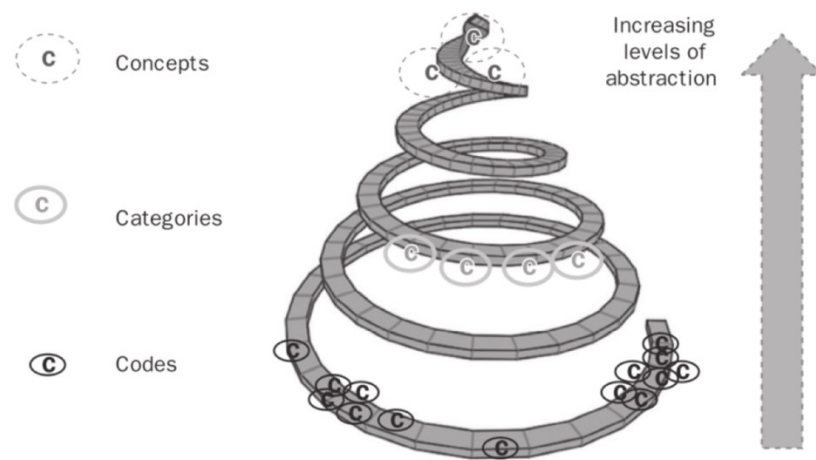


Fig 4.2 The Spiral Abstraction: Codes, categories, Concepts – increasing levels of abstraction(Bryant, 2017, p.97)

PART II. THE DISCOVERY OF CO-MEANINGFULNESS IN CoLAB

In PART II, we will enter our study of CoLAB Learning. The whole PART II can be divided into two sub-parts. The first sub-part, from chapter 5 to 7, concerns the socio-cognitive perspective of CoLAB whereas the second sub-parts, from chapter 8-11, concerns the socio-cultural perspective of CoLAB.

As we have reviewed in chapter 1, the socio-cognitive perspective and socio-cultural perspective are the two key perspectives in studying collaborative learning in the constructivist paradigm. Here we inherit these two perspectives as we believe they are both important and relevant in answering our initial questions. Since we take both perspectives, our final result of “Co-Meaningfulness” presents a hybrid feature of both, which we will discuss at the concluding chapter, chapter 12, of this PART.

We use the constructivist grounded theory method. Through a detailed case study of “Jumping Video” from the socio-cognitive perspective, we generate the key category of “Co-Meaningfulness” and its key properties. Then the “Co-Meaningfulness” is studied with a socio-cultural perspective, which connects this concept to the socio-historical experience of the learner and the socio-cultural context of the learner community. The whole grounded theory study is a continuous and iterative inquiry and theorizing, the development of which is summarized and visualized at the end of this PART in chapter 12.

Chapter 5. The Socio-cognitive Perspective of CoLAB

5.1 Introduction to the Socio-cognitive Perspective of CoLAB

The socio-cognitive perspective of CoLAB is studied in Chapter 5, 6 and 7. The purpose of studying CoLAB from the socio-cognitive perspective as the starting point, is to understand how people interact and collaboratively learn in the CoLAB setting. We do not hold too much preconception in the study, except for understanding the process is essentially complex and very often not easy. This leads us to the initial questions around the challenges of CoLAB learning process, for example:

- What are the main challenges do they find in the communication and collaboration?
- What works (or not) in the communication and interaction in overcoming these challenges?
- What process in overcoming these challenges has led to learning and creativity?

With these initial questions, we start to study the socio-cognitive process in CoLAB. With the socio-cognitive perspective, the microscopic collaboration and learning is at the center of our focus. As we are particularly interested in zooming into the collaborative learning process, unlike many other grounded theory research that focuses on personal reflection(e.g. from interpreting interviews), we focus on the conversation and interaction detail and try to compare and analyze them with grounded theory. This approach is from the research tradition in the socio-cognitive perspective of collaborative learning.

We start with the micro analysis of the small group collaboration but bearing in mind that the socio-cognitive process is inherently related to a larger social context. Therefore, the final concepts generated in the grounded theorizing process present both an interactionist and a socio-cultural perspective. The interactionist perspective is more thoroughly studied from chapter 5 to 7, whereas the socio-cultural perspective is more comprehensively discussed in the chapter 8 to 11.

We adopt the constructivist grounded theory approach. In this sub-part, the study is based on an in-depth investigation into a case project: “Jumping Video”. This project took place in one of the workshops we observed and appeared to be a typical CoLAB learning containing rich group interactions of different patterns. It is also a CoLAB process that features typical challenges and how learners interact to face these challenges. Therefore the “Jumping Video” is purposively sampled for the socio-cognitive study.

By a two-step grounded theorizing (initial coding -> focused coding), we are able to generate a key category, i.e. the Co-Meaningfulness, and its two key properties, i.e. “M-M Coherence” (short for Meaningfulness-Meaningfulness Coherence) and “P-M Intensity” (short for Project-Meaningfulness Intensity) to theorize the socio-cognitive process. Moreover, we generate a visual presentation for these concepts and properties as a framework for further categorizing and grounded theorizing.

The “Co-Meaningfulness” emerges as a key category in the coding when students find it not enough just communicating on the “project” level, and that they have to communicate and negotiate which part of the project is more “meaningful”. The understanding of “meaningfulness” appeared quite

divergent in the beginning but gradually changed in the course of the workshop. The phenomenon of constructing “Co-Meaningfulness” is discovered as an underlying but significant process in CoLAB learning, especially salient when the group faces challenges in the collaboration.

“M-M Coherence” and “P-M Intensity”, as two properties that characterize “Co-meaningfulness” are discovered as we closely compare the different episodes of the project in finding out why and how their “Co-meaningfulness” changes over time. The “M-M Coherence” means how coherent the group member’s meaningfulness are related to each other. The “P-M Intensity” means how actively group members engage their meaningfulness into their project - e.g. are they fully engaging, efficiently communicating or are they compromising their meaningfulness. We propose these two properties as two dimensions to describe the different status of the evolving “Co-meaningfulness”. The “Co-Meaningfulness” and the properties of “M-M Coherence” and ‘P-M Intensity’ are the key results of the socio-cognitive perspective study of CoLAB.

All these concepts were generated with close reading, coding and conceptualizing of our data, which includes interviews of key participants and key conversation during the workshop, all voice recorded, transcribed and translated into English (originally in Chinese). Also, research memos written during the closing reading are also used as part of the data. All participants received oral inquiry for consent on the data collection and interviews and confirmed their consent. We receive and follow the research ethics guidance from the Center for Research and Interdisciplinarity for conduction this research.

The initial study in this part generates the first set of categories and concepts that are used to analyze the socio-cognitive process. It builds the first bones and skeleton of our study but does not adequately answer a few important questions like what exactly “Meaningfulness” means for a learner, especially concerning to their historical experience. These questions need to be answered with more theoretical sampling for the socio-cultural perspective of CoLAB, which is elaborated in chapter 8,9,10 and 11.

We give the basic structure of the socio-cognitive perspective from Chapter 5 to 7.

Chapter 5 introduces the general structure of chapter 5 to 8 as well as the project “Jumping Video”, on which we base the grounded theory of this sub-part. It gives the context of the workshop and the project, e.g. information of mentors and participants, as well as the main content and development of the project during four days. The introduction will present the key elements of the

“Jumping Video” so that readers can be more familiarized with the case in the following grounded theorizing.

Chapter 6 presents the grounded theory methods we apply to the data. We apply Charmaz’s “constructivist grounded theory” approach. We present our method in detail which unveils how the key category of “Co-meaningfulness” emerge.

Chapter 7 is a detailed analysis of the case “Jumping Video ” with regard to the category of “Co-Meaningfulness”. We compare the different episodes and conclude “M-M Coherence” and “P-M Intensity” as the two properties of “Co-meaningfulness”.

5.2 The Case of “Jumping Video”

We based our socio-cognitive study on a case study of “Jumping Video”. In this section, we will introduce the project of “Jumping Video”, based on the field notes, conversation recording and research memos (see Appendix A).

Choosing the Project “Jumping Video” is a purposive sampling. One of our main motivation of investigation is to understand the challenges in CoLAB process. The project “Jumping Video” is one of the most representative CoLAB learning experience that features rich types of challenges.

These challenges and the attempts to solve these challenges drive the whole learning experience of the group. There are a number of key moments in the whole process, through which the group clearly transit from one stage to another in their collaborative learning. These stages are different: sometimes the group appears quite silent, sometimes they are very excited, and sometimes they argue fiercely over certain topic in their learning. In the post-interview, they also report that they believe their process is the most complicated and most interesting process compared to other groups or to their other experiences of with-in boundary learning, and they believe their process presents typical situations and challenges in CoLAB (Appendix A2.1). This self-report aligns with our observation, thus we decide to purposively sample this project as our key case study in the socio-cognitive perspective of CoLAB study.

We divide the whole development of the project into 6 episodes. The whole learning is a 4 day-long collaborative learning, therefore dividing the very long process is helpful for our analysis. We divide the whole process primarily based on the natural division of time: e.g. the Episode 1 is the first day, the Episode 2 and 3 is the second day morning and afternoon, Episode 4 is the

third day morning, Episode 5 is the third day evening, Episode 6 is the fourth day. But as the natural division of time also causes the change of learning focus and topic, these episodes also feature the different stages of their learning process, presenting very different group dynamic in each episode.

In this chapter, we will present the important events in each episode to give a general outline of the project. But we strongly recommend the readers to refer to the Appendix A, if they are interested in the details of the project.

Workshop “Smart Movement”

“Jumping Video” was a student project created in one of the interdisciplinary workshop we observed. The workshop “Smart Movement” was designed to explore the integration of design, smart device engineering, and the physics concept of “Movement”. Students from design, science and engineering, formed interdisciplinary groups to work on a project which must be related to the measuring movement with smart device. But other than that requirement, students were free to define their own project. Students are encouraged to come up with solutions to open wicked problems such as education, health, digital entertainment, with the “Smart Movement” device. The workshop features all the three features of CoLAB – open wicked problems oriented, collaborative learning and learning across boundaries.

The workshop took place from Dec 13 to 17, 2016, in an interdisciplinary design master program⁸ in Open FIESTA center, Tsinghua University, Shenzhen China. The 5-day workshop was started by a brief introduction with design prompts on Day 1, and ended by a conclusive presentation to the general public on Day 5, leaving roughly 4 whole days for the groups to make their own projects from scratch. Our observation focused on the 4 days where the group worked on their project.

There are in total two mentors for the workshop: Professor Jo and Ph.D candidate Ke (Ke is also author of this research). Professor Jo organized the workshop while Ke facilitated the students at the same time observed the workshop.

Jo gave the general topic in the beginning and facilitated the student's discussion and prototyping throughout the workshop. The mentors also brought in a hardware tool called “movuino” to help the students to prototype. This tool is an easy-to-program chip for movement measurement and

⁸ ID (Innovative Internet+ Design) program in Open FIESTA (Faculty of Innovation Education of Science Technology and Art) Shenzhen, China.

recognition. Ke gave guidance to this tool as an optional session for those who need help in implementation.

The group of “Jumping Video” consisted of three members, a male engineer, a female mechanical engineer and a female designer, all in their first year Master. They all had been well trained in their bachelor degree respectively in their disciplines and were then just entering their interdisciplinary master program “Innovative Design for the Internet Plus Era”.

Mentors and Participants

Xid, student, design background, team member who followed the whole project

Ming, student, engineering background, team member who followed the whole project

Ren, student, Mechanical engineering background, team member who followed part of the project

Ke, Mentor, Ph.D candidate, background in physics , interaction design, social science

Jo, Mentor, a physics professor who also hosts many interdisciplinary design workshops

Li, external observer, bio engineering background.

(All names are pseudonyms)

Xid, Ming and Ren are the three master students working on the project. Ke and Jo are the mentors, and Li is a staff of Open FIESTA who sometimes joined the conversation.

Jo is a French physics professor, but he is also keen on the new ways of teaching physics, especially with the help of smartphone applications. Before the workshop, he had developed a smart phone application by which students can explore the physics concepts such as velocity, acceleration, oscillation, etc. with the built-in accelerometer and gyroscope. Inspired by this new way of teaching and learning, Jo started to explore other possibilities that can make use of the “movement” measurement, e.g. in health, education, and sports, etc. That was where Jo started to work with designers as they can sensitively discover and design these concepts and applications. The exploration

process then became a CoLAB learning as Jo organized workshops to bring together designers, engineers and scientists to co-create their own projects. And this Open FIESTA workshop was one of his early (but not the first) attempts.

Ke is a Ph.D candidate, and also the author of this research. He participated at the same time observed Jo's several "Smart Movement" workshops. Ke studied physics in his bachelor and interaction design in his master. Therefore Ke has both background to understand the different perspectives. Ke is Chinese, and before his Ph.D life in Paris, he did his master in Tsinghua University, China. He is familiar with both the academic and social context in this workshop.

Xid is a design background student, she studied industrial design and interaction design in her undergraduate. She is quite familiar with the workshop format, but she also felt this workshop was quite unique as the mentor has a physics background thus brought new perspective she had never experienced in a pure design environment.

Ming has an engineering background, and he studied optics and electronics in his undergraduate. He had also joined design workshops a few times before this workshop. In one of his internship during undergraduate, the technology company often invited designers to discuss and he enjoyed the mixed perspective.

Ren has a mechanical engineering background, and she is a classmate with Xid and Ming in the interdisciplinary program. Ren only joined part of the workshop as she had other duties.

The Project "Jumping Video" by Episode

Here, we present the project "Jumping Video" by episodes. As we said the episodes are mainly divided by time. We correspond the episode with the line number of the transcription in the Appendix A1.

Episode 1. The Selfie Stick (Line. 1-28)

The Episode 1. (corresponding to Line 1-28 in the conversation transcription) took place on Day 1 in the classroom.

The group just started their brainstorming and they were discussing on one idea of a special selfie stick(see Fig. 5.1). The selfie stick was essentially Ming's idea. Ming wanted to mount a lighting device (the red frame-like part in Fig. 5.1) onto the selfie stick so that the selfie stick itself can fill light (the red lines emitted towards the user in Fig. 5.1) when needed, e.g. when the user is

in dark environment or wants to fill extra light. The group was mainly discussing how to implement this idea but not so much on the purpose of the project.

The episode ended as they found out their idea cannot meet the workshop requirement, as it did not address enough the concept of “movement”. They had to change the project.

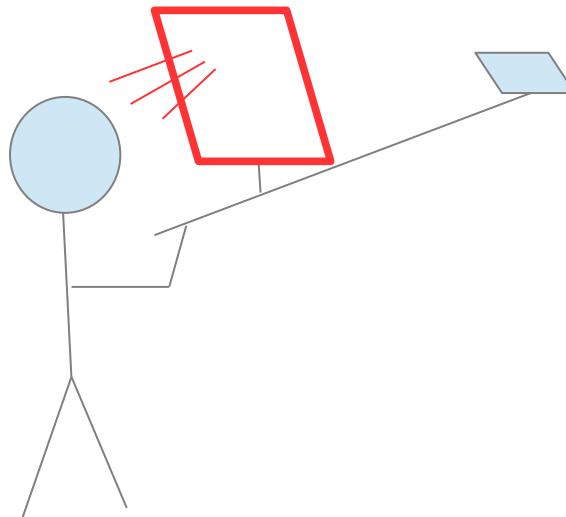


Fig. 5.1 Illustration of the Selfie Stick Idea in Episode 1

Episode 2. New Proposition (L.30-60)

The Episode 2. (corresponding to Line 30-60 in the conversation transcription) took place on Day 2.

The next day, as the group found out their previous idea did not fit the workshop, they started to look for new directions. As Ming was the main contributor of the first idea, Xid wanted to propose something she is interested in this time. Inspired by the lighting concept, Xid wanted to design a camera system that corresponds to the movement of the subject being photographed. Xid focused on the experience of the subject while Ming was focusing on what specific lighting effect to design. This divergence gradually became a collaboration challenge for them. This Episode features how they coordinated their divergence.

Episode 3. Getting Stuck (L. 61-170)

The Episode 3. (corresponding to Line 61-170 in the conversation transcription) took place on Day 2.

Li came and joined the conversation. But his constant challenging did not help very much in the project progress. They seemed to get stuck.

With little progress, they even considered giving up and changing again. The new idea however did not last long as it too did not fit the workshop requirement.

Episode 4. Mutual Understanding (L.171-231)

The Episode 4. (corresponding to Line 171-231 in the conversation transcription) took place in the daytime of Day 3. The team gradually fixed the idea, and they started to work on the details. Ke helped them to grow the mutual understanding in this episode. At the end of the episode, Ke urged the group to go out and try out their first prototype.

Episode 5. Going Outside (L. 232-273)

The Episode 5. (corresponding to Line 232-273 in the conversation transcription) took place in the evening of Day 3.

This episode featured a creative moment after they successfully made their first prototype. All of the participants and Ke were quite satisfied with the final effect. The idea originated from Xid's idea of associating the subject's movement to the camera setting. And during the outdoor prototyping, they found out the best association would be to move the camera as the subject moves so as to create a special moving effect. For example, Xid rotated the camera while Ming at the same time rotated his skateboard he stepped on.

Episode 6. The Big Fight (L. 275-443)

The Episode 6. (corresponding to Line 1-28 in the conversation transcription) took place on Day 4.

Although they fixed the most part of the project, they got stuck when naming the project. Xid and Ren had a different opinion on the naming. The naming conflict soon turned into a big fight over the general purpose of the project. Both Xid and Ren, who had conflicting opinions, felt very frustrated as they sensed the other did not understand their perspective. Ke helped in resolving the conflict at the same time explained to them the nature of the conflict. The group could finally fix their project before the presentation on day 5.

The different episodes present several up-and-downs in this CoLAB process with rich types of challenges and their attempts to resolve these challenges, which we will analyze in chapter 6 and 7.

Chapter 6. Coding and the Emergence of the “Co-Meaningfulness” Category

In this chapter, we start to analyze the project “Jumping Video”. The analyzing method we follow here is the “constructivist grounded theory” (Charmaz, 2006), a branch of grounded theory taking a constructivist perspective (see chapter 4 for a full review). The grounded theory helps us to sort and category the data as we construct the grounded theory useful in interpreting the socio-cognitive process.

As we want to zoom in and understand the micro scenarios in-depth in the socio-cognitive perspective. We largely rely on analyzing the recorded conversation, supplemented by interviews and researcher’s memos. This choice inherits the tradition of collaborative learning research in the socio-cognitive perspective (see chapter 1.3 for more detail).

6.1 Initial and Focused Coding

Initial Coding

In this chapter, we follow the constructivist grounded theory and adopt a line-by-line coding strategy as initial coding. We present two examples of the conversation and coding to illustrate how we code the data. For a full review of the conversation and coding, please see the APPENDIX.

First Example of Coding: (Line 30-43)

	Transcription of Conversation	Coding
30	Xid: Can you go back to the idea of selfie and light, but not focus on the selfie stick peripheral ? I think it's complicated to hack the stick, and we are not going to really hack it when we present. And we don't have a stick	Demanding a rewinding of idea; explaining rationale : too complicated; no material at hand
31	Ming: I just bought it.	Disagreeing on part of the rationale
32	Xid: I mean, we can return to the point of light effect.	Emphasizing on main demand
33	Li: how we can relate to movement	asking how to relate to workshop requirement

34	Ming: last time, when I took a photo of my classmate, and my hand shakes a bit , the effect was very good.	Recalling past experience to support a good effect – shaking photo
35	Xid: you know, what I am thinking is, let it shoot automatically, and you make crazy movements, dance, whatever, and then the it can fill light accordingly, same crazy.	Proposing new project idea; Describing the effect – crazy movement and light associated
36	Ming: OK	indicating understanding
37	Xid: Or maybe, I can wear the device and dance, and certain movement would trigger the shooting. And the light might adapt to the music.	Keep proposing new function and effect – dance and shooting trigger.
38	Xid: let's think about this scenario: in a dark photography studio, there's some colorful line light, some people are dancing. Maybe some movements would trigger the shooting, and then we can have very natural photo.	Proposing scenario – dark studio with colorful light. Proposing effect and purpose – natural photo:
39	Xid: just now, we were thinking about one person, but we could have multiple people interacting in it. I am just proposing this idea, you can also change it.	Proposing scenario and interaction – multiple people; inviting for advice
40	Ming: the trigger ?	Indicating confusion
41	Xid: just the shutter	Brief explaining
42	Ming: We haven't reached how we place these lights on the floor.	Asking question on technical detail – how to place light
43	Xid: We could describe the scenario as a dark room, we could also find a such place.	Answering by give a scenario

Table 6.1 Transcription and Coding of Episode 2, Xid and Ming discussing on the Project

The above excerpts demonstrated a small conversation in the beginning of the second day, when Xid started to think of a new project idea. Xid was actively thinking and giving new ideas, as the coding indicates: (Describing the effect, L35; Keep proposing new function and effect, L37; Proposing scenario – dark studio with colorful light. L38) while Ming inactively accepted or raised confusion (indicating understanding, L36; Indicating confusion, L40). Their conversation covers a wide range of the different properties of the new idea, e.g. its effect, function, scenario, technical detail, etc. (support a good effect, L34; Describing the effect, L35; Keep proposing new function, L37; Proposing scenario – dark studio with colorful light. L38; Asking question on

technical detail – how to place light, L42). The initial codes exhibit the primary analytical choice we make, which is to highlight the actions as well as the objects we code. The coding of conversation is a first attempt to generate the first set of raw analytic codes, and the next step is to read and compare extensively in finding the most useful codes that can be applied to further analyzing. We will come to the analysis of these codes in the next chapters and sections.

Here is a second example of Initial Coding: (Line 161-170)

	Transcription of Conversation	Coding
161	Ke: you know there is a camera, it's actually a ball, with a fish-eye. You can throw it in the air, and it can take a panorama at the top.	Relating to examples with technology
162	Xid: look this is just now, my two friends takes the capture picture.	Friends prototyping
163	Ke: if we leave out the light. We can follow the camera drama workshop. The title means the camera itself is a drama.	directing to refer to examples
164	Xid: if you fix the camera to the bicycle, you would get a very rotating video.	Proposing new scenario and effect.
165	Ming: Like astronauts training.	Making metaphor
166	Xid: so we need a conclusion.	Urging to conclude
167	Ming: we had already a lot of change of ideas now, before camera shake, light. Tonight, we focus on movement and camera.	Concluding previous work
168	Xid: let me state again what I believe is meaningful in my proposal. First is, the randomness. You don't know when the camera will take the picture. Second the moment you record is very natural. Sometimes when we take picture, it all looks the same as if they can have only one expression on their face. You can change the form but express the same feeling.	Clarify meaningfulness Highlighting random as meaningful Natural picture meaningful Dislike same expression
169	Ming: Or we don't let the movement control the camera, we can let the movement control the light.	Emphasizing Light control

170	Ke: I think we had enough talk. I like the idea. One thing I want to add here is special moments have special meaning. The interaction itself should have meaning. Her idea is the trigger itself is movement. Photography itself can connect to movement. Can be the angle, can be the shutter speed, can be settings , can be blurred at some moment. Some movements can be defined by the camera to be wide FOV, some movements defined to be like from an animals' eyes. There is a lot to play here, but not talk. You need to play with the movements. Like the can't touch example, we designed all the movement, for a whole day. There's a lot of space to play it. I think the idea is good, worth playing and testing.	Approving the project idea Associating moment to meaning Mentioning more parameter Encouraging "playing" Recalling "example" Emphasizing testing

Table 6.2 Transcription and Coding of Episode 2, Xid explaining her Meaningfulness

In this above example, the group was struggling to fix a concrete project idea and Ke suggested them to play and test. (*Encouraging "playing", Emphasizing testing, L170*) . Besides working on the specific project idea, Xid also explains explicitly what is really meaningful in the project, e.g. randomness and taking pictures with a natural feeling. (*Clarify meaningfulness, Highlighting random as meaningful, Natural picture meaningful, L168*).

Focused Coding

A close reading of the codes leads to focused coding of the socio-cognitive process in "Jumping Video". Two focused codes emerge from our initial coding:

The "Project", the most salient code

The frequent emerging code is the "Project" the students worked on. Learners constantly propose and accept/reject new ideas for the "Project"(e.g. *Describing the effect, L35; Keep proposing new function and effect, L37;*) , as well as to comment, approve or criticize existing "Project"(e.g. *Indicating confusion, L40*).

The “Project” is not a single object. For example, students can discuss on the “Effect” of the final presentation or the “Function” of certain parts, or they can argue on the “general purpose” for the “Project”. There are also different actions associated to the “Project”. The following table (Table 6.1) summarizes the focused code of “Project” and its sub-categories emerging from the initial coding(see APPENDIX A1).

Project	
Sub-Categories	Initial Codes
Project Components	general goal, effect, scenario, function, technical detail, inspiration
Work-in-progress Project	Project, whole Project, general Project
Project-associated actions	
Sub-categories	Initial Codes
Proposing	proposing new... , raising new... , Introducing, asking for.. , inviting, getting inspired, adding/reducing, encouraging, mentioning, showing
Accepting	admitting, feeling (positive), supporting, agreeing, approving
Falling problematic	questioning, denying, feeling (negative), exposing problems, rejecting, disagreeing, confusing, hesitating, abandoning, disliking,
Coordinating	asking, choosing, solving...problem, demanding, explaining, emphasizing, recalling, insisting, giving examples, justifying, avoiding, elaborating, arguing, rephrasing, prototyping, highlighting,clarifying, self-repairing, completing, understanding, concluding, pointing out, advising, confirming, presenting, debating, speculating, pushing for, describing, discarding, (re)affirming, focusing, reminding, mentioning, thinking

Table 6.3 The focused code of “Project” and its sub-categories in terms of “Project” and “Project-associated actions”, categorized from the initial codes

The blue part in the above Table 6.1 presents the sub-categories of “Project” as an object, whereas the yellow part presents the sub-categories of “Project-associated actions”. Since the “Project” is a very common code, all these sub-categories emerge from the extensive initial coding (see APPENDIX A1 for full initial codes), which we present in the right column to the sub-categories column. We explain each of the sub-categories in the following:

1. Project: “Project Components” and “Work-in-Progress Project”

The project does not always appear as a whole, very often the learners will propose part a function, an idea, a specific effect. The sub-categories of “Project Components” indicates these different parts of the “Project”. The following table 6.2 lists the different components in the “Jumping Video” case.

Components	Description	Examples
General Goal	Why the group members build their project : what problem to solve and why in the proposed way	<i>Li: I think it's not time for all this details. For recording this, I don't think there is a lot of need of this.</i> <i>Xid: The goal is sometimes when we take pictures, we make poses that are not very natural.</i> (Line 97-98)
Effect	Targeted presentation of project result upon realizing : realization of the General Goal in concrete forms	<i>Xid: shake ? so we make a camera that looks shaky.. No .. a camera that take pictures while shaking ?</i> <i>Ming: yes, or like before, there are some apps turning clear pictures into vintage, glitchy or random effect.</i> (Line 128-129)
Scenario	Where and in which situation the Project is going to be presented or used	<i>Ming: We haven't reached how we place these lights on the floor.</i> <i>Xid: We could describe the scenario as a dark room, we could also find a such place.</i> <i>Ming: no. I mean how you can place and fill the light.</i> (Line 42-44)
Function	A specific design as one part to serve the entire design and functionality of the Project	<i>Xid: I meant to have colorful light as new function. It can change according to music ... it might be fun.... Can it rotate? No, right? Actually I was thinking about spot light. That might be fancy. But now we have only point light. In worse case, we post-process.</i> <i>Ming: we need to have a demo live right ?</i>

		(Line 59-60)
Technical Detail	Specific implementation details to achieve Function	<i>Ming: we can test many modes with this. E.g. filter like light etc.</i> <i>Xid: I think foldable .. we need to know the technical detail</i> <i>Ming: reflection board it's foldable</i> (Line 21-23)
Inspiration	Thoughts, ideas, and examples that inspires other components of the Project	<i>Xid: iphone 6s. XM, you remember LIN took a picture of you, and you were moving like this. The picture looks so great. Very funny.</i> <i>Xid: So if we use the inspiration, we just need to set several movement to trigger the camera.</i> (Line 116-117)

Table 6.4 List of Different Components of the “Project” in “Jumping Video”

Besides the “Project components”, there are also occasions when the learners will need to refer to the whole work-in-progress project. This sub-category often appears “project”, “whole project”, “general project” in the initial coding.

2. Project-associated actions: “Proposing”, “Accepting”, “Falling problematic”, “Coordinating”

In the sub-categories of “Project-associated actions”, we select four important sub-categories which categorize the different actions learners conduct in their learning. The following relation map(Fig. 6.1) summarizes their relations to the “Project” in the CoLAB process.

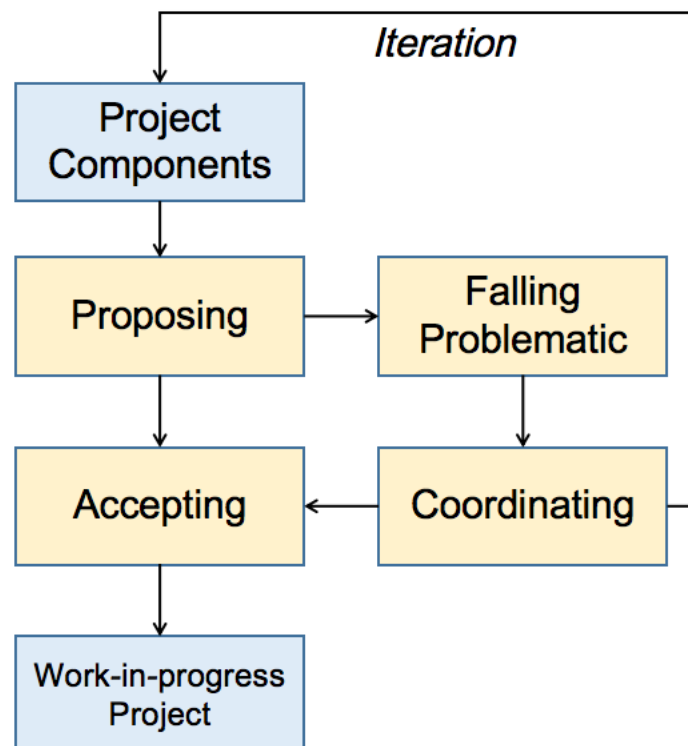


Fig. 6.1 The socio-cognitive CoLAB process presented by the sub-categories of “Project” and “Project-associated actions”

In the above illustration, first, the different learners propose their different project components to construct their project, actions of which we categorize as “Proposing”. Initial codes such as “propose new...”, “introducing” etc. are categorized as “Proposing” (see table 6.1 for more detail).

Two situations will happen after proposing. Either the proposed component is accepted into the work-in-progress Project, which is the sub-category of “Accepting”, or becomes a problem, which is the sub-category of “Falling Problematic”. The “Accepting” category often features actions such as “admitting”, “supporting”, “agreeing”, etc., whereas the “Falling problem” is often associated with initial codes such as “questioning”, “denying”, “confusing”, etc. After “Falling Problematic”, the group will need to coordinate their problems, the process of which is presented by initial codes such as “explaining”, “choosing”, “advising”, etc. We code this process as “Coordinating”. The result is either accepted or remains to be a problem which leads to a new round of iteration by proposing new and more project components.

The “Meaningfulness”, the important but underlying focused code

The second focused code is the “Meaningfulness”: Students do not only communicate on the “Project” Level, they also explicitly or implicitly exchange

on the “Meaningfulness” level. They state or imply which part of the “Project” they believe as more meaningful.

The code of “Meaningfulness” is important, as it appears in situations where the students find it difficult to mutually understand or where the students feel urged to express their preference of meaningfulness. Often these situations mark important turns or key moments. But it is also not so frequent as students do not very often explicit discuss at the meaningfulness level. The code of “Meaningfulness” is important but underlying.

Hence we cannot present a full summary of the sub-categories of “Meaningfulness” emerging from the extensive initial codes, as we did for the code “Project” in Table 6.1. The more comprehensive analysis of the sub-categories and properties of this code will follow in the next chapters. But here we will use a few examples to explain the basic meaning of this key focused code.

In Table 6.5, Xid and Ming were debating on the how the light should be placed – a “function” and “Technical Detail” of the “Project”. But the discussion upgraded to the level of implicit “meaningfulness” exchange when Xid explained she believed “We are for fun... I think a design should first touch people.”(L. 57) while Ming opposed to her as she “omit all the detail” and “not such fun”(L. 58). Apparently they held a divergence in understanding which part of the “Project” is more meaningful when tackling the same component of the “Project”.

52	Ming: But the prototype is after the written description right. Prototype is for demonstrating the idea, which include the light.	Rejecting, insisting on including the setting.
53	Xid: i think B light (?) should work. We can buy a curtain, and then we can take the picture.	Proposing a specific setting
54	Ming: yes, we could think twice on the detail.	Agreeing on more thinking
55	Xid: you think it will work ?	Asking for agreement
56	Ming: yes. I am now thinking maybe we can just use top light .	Agreeing; proposing new setting and effect – top light
57	Xid: can be multiple light, we might also refer to the MF room. But that is very professional. We are for fun. How people can really play with it. I think a design should first touch people.	Proposing new effect – multiple light; exhibiting implicit purpose: having fun , touch people ;

58	Ming: yes, this point is very important. And this actually contribute to my points. Because you say it would be fun, but you omit all the details, it's very abstract now. One beam of light is not such fun.	Accepting the meaningfulness of fun; opposing neglect of specific effect is fun; abstract not fun

Table 6.5 “Meaningfulness” Example 1: Having fun as Meaningfulness

In the following excerpts of Table 6.6, the “Meaningfulness” is much more explicit as Xid deliberately stated her belief in what is meaningful: randomness and natural picture (L.168).

16 6	Xid: so we need a conclusion.	Urging to conclude
16 7	Ming: we had already a lot of change of ideas now, before camera shake, light. Tonight, we focus on movement and camera.	Concluding previous work
16 8	Xid: let me state again what I believe is meaningful in my proposal. First is, the randomness. You don't know when the camera will take the picture. Second the moment you record is very natural. Sometimes when we take picture, it all looks the same as if they can have only one expression on their face. You can change the form but express the same feeling.	Clarify meaningfulness Highlighting random as meaningful Natural picture meaningful Dislike same expression

Table 6.6 “Meaningfulness” Example 2: Randomness as Meaningfulness

In the following excerpts of Table 6.7, Xid and Ren were debating on the naming of the “Project”. Ren insisted on a simple name “Jumping Video” which to her is more understandable(L. 290, 292). But to Xid, she preferred another name “You Jump I Jump” because she believed the “association” of “movements” is key meaningful aspect in the Project and should be reflected in the name (L. 289, 295).

289	Xid: I think our product's focus is the association so “you jump, I jump” can highlight the association	naming presenting “association” as meaningful
290	Ren: but the users wouldn't know the activity then	naming not understandable
291	Xid: but if you put “jumping video”, it's still strange, why would it jump?	feeling awkward naming meaningless

292	Ren: “Jumping video” is the visual effect. How do I know what you meant by “you jump I jump”?	naming not understandable
293	Xid: but “jumping video” doesn’t sound catchy. will be disadvantaged when selling. Secondly “jumping video” doesn’t have a reason. Our point, the focus is the association, not that it can jump. Everything can jump.	naming not catchy naming meaningless emphasizing on “association”
294	Ren: but what if users never heard of the background of “you jump I jump”, would they understand? ...	naming not understandable lacking context
295	Xid: But “you jump I jump ” is just an association.	repeating “association”

Table 6.7 “Meaningfulness” Example 3: Effect of “Jumping” Being Meaningless

As we have extracted from the coding, the “Project” is not a single object, but a developing object with different components. Therefore, when different people approach the “Project”, they naturally look for the “components” most fitting what they believe is meaningful. For example, Xid would approach the “Project” from the perspective of “association” and “fun experience”(Example 1,3), while Ming would grab the handle of “lighting detail” (Example 1). The “meaningfulness” differences will result in different perspective, different emphasis and even different interpretation of the “Project” itself, which often cause difficulty in mutual understanding and key turns, as shown in the Example 1,3.

The Meaningfulness in the “Jumping Video” is inherently related to the “interdisciplinarity” of the workshop. As Xid explained in her post-interview(see A2.2 in Appendix), the “association” is not only what she found meaningful in this particular Project, it was also what she believed where the essence of interaction design lies. For example, she believed the whole workshop theme was in a designerly way because it “associated” the “movement” to the “smart technology”. At the same time, Ming’s meaningfulness of “working out the detail” was also not only present in this project, he explained the biggest fulfilment in his undergraduate course was to independently implement many types of technology in a single project, which inevitably included working out different technology details.

To conclude, there are two major focused codes from the initial and focused coding: (1) the pervasive code of “Project” and (2) the underlying but important code of “Meaningfulness”. A few conclusions can be drawn from analyzing the two codes and the data where the codes emerge:

- The “Project” is not a single object, it is a complicated and developing object, with multilayer of “Project components”.
- The “Project Components” enters the “Work-in-progress Project” through coded process of “Proposing”, “Accepting”, “Falling Problematic” and “Coordinating”, and sometimes it requires iteration.
- Participants often grab the “Project Components” that best fit their meaningfulness. And if they have different meaningfulness, it might eventually cause different interpretation and misunderstanding.
- Divergent meaningfulness causes coordination and communication of Meaningfulness in addition to the communication and coordination of “Project”

6.2 Analyzing One Challenge and the Category of “Co-Meaningfulness”

A “Meaningfulness” Case

Our focused coding selects “Meaningfulness” and particularly its relation to the “Project” as a significant analytical starting point. In this section, we will analyze one of the cases where the code of “Meaningfulness” emerges in order to deepen our understanding with further coding and sub-categorizing. This step is necessary as “Meaningfulness” is an underlying phenomenon, thus a simple “counting” and “categorizing” strategy will not generate insightful analysis of the underlying mechanism of the phenomenon. We need to delve into the specific case and reply on deep and iterative analysis to guide the grounded theory.

The excerpts are taken from the Episode 2 from line 38 to 60(see Table 6.8), where Xid and Ming were arguing on a new proposition of Xid. In the first part of this conversation(line 38-46), Xid and Ming started to realize they have disagreement beyond the “Project” level which led them to communicate their meaningfulness. In the second part(line 47-60), they started to deeply communicate on the “Meaningfulness” trying to find out what results in the disagreement and trying to fix it.

38	Xid: let's think about this scenario: in a dark photography studio, there's some colorful line light, some people are dancing. Maybe some movements would trigger the shooting, and then we can have very natural photo.	Proposing scenario – dark studio with colorful light. Proposing effect and purpose – natural photo:
39	Xid: just now, we were thinking about one person, but we could have multiple people interacting in it. I am just proposing this idea, you can also change it.	Proposing scenario and interaction – multiple people; inviting for advice
40	Ming: the trigger ?	Indicating confusion
41	Xid: just the shutter	Brief explaining
42	Ming: We haven't reached how we place these lights on the floor.	Asking question on technical detail – how to place light
43	Xid: We could describe the scenario as a dark room, we could also find such a place.	Answering by give a scenario
44	Ming: no. I mean how you can place and fill the light.	Refusing answer; repeating questions.
45	Xid: it's the realistic part, but we are now doing a prototype, we don't need to go that far right ?	Rejecting the need to further discussion on the realistic part; providing rationale: prototype
46	Ming: But even for a prototype, you need to think about these in order to present/express the idea.	Rejecting rationale; arguing on the prototype's presentation
47	Xid: what do you mean ?	expressing confusion
48	Ming: meaning that if you want to present the idea, you need to, for example, the light projected on the dancer can have certain effect. Dancer... the certain movement ...	Emphasizing on the detailed effect as part of the prototype
49	Xid: the prototype is mainly for describing the basic function and then a good video or picture to showcase.	Rejecting the understanding of prototype; providing an alternative understanding of prototype
50	Ming: but if the function includes the light, then we must decide where the light came from and where it projects to.	Insisting on the specific setting

51	Xid: this should be included in the written description. We don't need to include it in the prototype.	Excluding the detailed setting from prototype
52	Ming: But the prototype is after the written description right. Prototype is for demonstrating the idea, which include the light.	Rejecting, insisting on including the setting.
53	Xid: I think B light (?) should work. We can buy a curtain, and then we can take the picture.	Proposing a specific setting
54	Ming: yes, we could think twice on the details.	Agreeing on more thinking
55	Xid: you think it will work ?	Asking for agreement
56	Ming: yes. I am now thinking maybe we can just use top light .	Agreeing; proposing new setting and effect – top light
57	Xid: can be multiple light, we might also refer to the MF room. But that is very professional. We are for fun. How people can really play with it. I think a design should first touch people.	Proposing new effect – multiple light; exhibiting implicit purpose: having fun , touch people ;
58	Ming: yes, this point is very important. And this actually contribute to my points. Because you say it would be fun, but you omit all the details, it's very abstract now. One beam of light is not such fun.	Accepting the meaningfulness of fun; opposing neglect of specific effect is fun; abstract not fun
59	Xid: I meant to have colorful light as new function. It can change according to music ... it might be fun.... Can it rotate? No, right? Actually I was thinking about spot light. That might be fancy. But now we have only point light In the worst case, we post-process.	Proposing new effect and function: colorful , spot light. Proposing
60	Ming: we need to have a demo live right ?	Inquiring on presentation format

Table 6.8 Discussion between Ming and Xid on Xid's new idea, conversation taken from Ep. 2 (L.38-60)

The first key moment of misunderstanding can be detected in Line 42, when Ming invited Xid to discuss on one specific problem: “how to place these lights on the floor”. In response to Ming, Xid simply omitted Ming's literary meaning, and started to introduce a scenario (dark room) to the “project”, but that does not answer Ming's question.

This was a very important moment that marked the starting point of misunderstanding. Xid interpreted the Ming's question as a question concerning the "scenario" rather than the installation "detail". Therefore Xid answered by giving a "dark room scenario", which is not what Ming expected. Not being answered, Ming repeated and clarified his question (L. 44), which made Xid to realize what she proposed did not answer Ming's question. And from the later discussion, we can infer that the reason for this mismatch is that **Ming believed the specific Effect is more important, but Xid believes the abstract interaction more meaningful**. We use the following further coding (in blue) on the meaningfulness in Table 6.9 to present this analysis of Ming and Xid's underlying meaningfulness.

42	Ming: We haven't reached how we place these lights on the floor.	
43	Xid: We could describe the scenario as a dark room, we could also find such a place.	
44	Ming: no. I mean how you can place and fill the light.	
45	Xid: it's the realistic part, but we are now doing a prototype, we don't need to go that far right ?	imply meaningfulness – the abstract interaction
46	Ming: But even for a prototype, you need to think about these in order to present/express the idea.	imply meaningfulness – specific Effect

Table 6.9 Meaningfulness Coding 1: Discussion on Xid's new idea @Ep. 2

Why in the first place did Xid omit Ming's point? From what she explained later we know she was able to understand what Ming tried to introduce to the "Project", but she failed to interpret correctly. When Ming asked about how to set the light, **Xid interpreted the question to be "how to set up a scenario to best facilitate the interaction and have good user experience"**, which led to her answer of a "dark room". She couldn't understand why the details of light position is worth discussing there: "Why would Ming bother to think about the light? This is irrelevant to the meaningful part of the project."

Xid focused on abstract association between technology and human, this intuitive thinking is very natural for her since she was trained in interaction design(see Appendix A2.2). She knew how this interaction might conceive rich content for further development. Ming, on the contrary, focused on the specific Effect – how exactly they are going to place the light so that it will be a creative and meaningful project for him. This intuitive thinking is due to his engineering background, which emphasizes a more realistic and practical meaningfulness. Up to now, we haven't seen any explicit explanation of

meaningfulness, Xid and Ming were trying to communicate the meaningfulness through discussing on the “Project” level.

The second key moment followed right after. In Line 57, Xid said, “We are for fun”, “I think a design should first touch people”, all central to her meaningfulness. Xid clarified her meaningfulness because she sensed that Ming did not share the same ground. Therefore she had to made explicit of what she believed to be more meaningful. In clarifying “having fun” and “touching people”, she tried to justify her omission of the realistic part. To her, Ming's proposition, focusing on realistic part, conflicted her intuitive thinking. She did not believe digging into the detail will be of any help to make her meaningful Project, but felt compelled to apply her principles of “having fun” and “touching people” into the Project.

Ming's immediate answer was even more interesting. Instead of disagreeing with Xid, Ming actually agreed to Xid's meaningfulness of “having fun”, by saying “yes, this point is very important” (L. 58). But Ming did not agree that omitting the detail would lead to “having fun”, by saying: “You say it would be fun, but you omit all the details, it's very abstract now. One beam of light is not that fun” (L. 58). His response implies his ultimate meaningfulness lies in the Specific Effect, not in the interaction – the Specific Effect would trigger and support the meaningfulness of “having fun”, but not the ‘having fun in interacting”, as Xid implied. We use the following further coding (in blue) on the meaningfulness in Table 6.10 to present this analysis of Ming and Xid's underlying meaningfulness in this second part of conversation.

56	Ming: yes. I am now thinking maybe we can just use top light .	
57	Xid: can be multiple light, we might also refer to the MF room. But that is very professional. We are for fun. How people can really play with it. I think a design should first touch people.	explain Meaningfulness – fun, touch people
58	Ming: yes, this point is very important. And this actually contribute to my points. Because you say it would be fun, but you omit all the details, it's very abstract now. One beam of light is not such fun.	imply Meaningfulness - Specific Effect
59	Xid: I meant to have colorful light as new function. It can change according to music ... it might be fun.... Can it rotate? No, right? Actually I was thinking about spot light. That might be fancy. But now we have only point light In the worst case, we post-process.	

Table 6.10 Meaningfulness Code 2: Discussion on Xid's new idea @Ep. 2

Ming seemed to agree with Xid's meaningfulness("having fun"), but in fact, they did hold different meaningfulness. And more importantly, this meaningfulness is not isolated, but exists in connecting their "Meaningfulness" to the "Project". When Ming tried to connect "having fun" to the project, he could not imagine the same "fun" as Xid would imagine. Therefore even if Ming can agree on the meaningfulness of "having fun", he cannot agree on the connection between the project which "omits detail" and the meaningfulness of "having fun".

In the very end (L.59), Xid's proposition was an attempt to incorporate the two different "meaningfulness" together. She finally gave details such as "spot light" and "music", but also did not throw away her meaningfulness of "having fun" ("it might be fun", L. 59). In this way, she tried to repair the divergence by proposing something that Ming might also find aligning to his meaningfulness.

The Category of "Co-Meaningfulness" Emerges

Analyzing the "Meaningfulness" case above helps us to extract a few important understandings that foreshadow the further categorizing and analyzing of the code "Meaningfulness":

Meaningfulness appears as the driving force for the "Project" interpretation and progress:

The misunderstanding caused by meaningfulness was not something they can just ignore. It is because the participants interpret the "Project" with their own glasses of "meaningfulness" on. For example, when Ming asked specifically about the light setting, Xid did not interpret it as a question about lighting but about a general scenario, as she believes the latter is more meaningful and worth developing. How participants interpret every proposition in the "Project", and in which direction they want to develop every progress in the "Project" might inevitably have something to do with their distinct meaningfulness. This phenomenon makes Meaningfulness a driving force for the "Project" interpretation and progress.

Meaningfulness is manifested in its association and application to the “Project”, not alone:

In most cases, Meaningfulness is communicated implicitly in the “Project” space. Only when discrepancies are big enough, will people start to reflect and foreground the meaningfulness. But even then, the Meaningfulness alone does not make independent sense, it has to be established and communicated with regard to the “Project”. Ming's “agree-and-disagree” reaction was a perfect example of this phenomenon: The meaningfulness of “having fun” was interpreted differently by Ming and Xid when they connected it to the actual “Project”. We can compare the “Project” to an ever-growing object with many handles, and participants’ Meaningfulness as hands to grab these handles. The influence of “meaningfulness” exists in the hands-grasping-handles action, not in their separated status or in the hands alone.

The collective status of the “Meaningfulness” matters:

If we only see “meaningfulness” as separate properties of each participants which independently influences the collective “Project”, we miss to see the rich dynamics of the collective meaningfulness that largely influence the group collaboration process. For example, In the beginning, it is not only Xid's own meaningfulness that produced the debate, but also her feeling of conflicting meaningfulness that compel her to state explicitly about “fun” and “touch people”. Later, it was also the “seemingly-align-actually-divergent” meaningfulness status that drove Ming to clarify his interpretation. In the very end, Xid proposed “color” and “spot light” with the intention to combine the meaningfulness of “fun” and “specific Effect”, and we can reasonably infer that the successfully combined meaningfulness will influence differently from the current conflicting status.

Therefore, the relation of different meaningfulness and their interaction do influence on the “Project”. The collective status of the “Meaningfulness” matters.

Meaningfulness has the potential to develop:

As the “Project” is developing in the course of CoLAB, so is the related “Meaningfulness”. In the above example, we can see at the end of the incident, Xid tried to combine their meaningfulness. The action has demonstrated participants intentionally change their meaningfulness. The develop of meaningfulness is very important if we are taking a developmental view of CoLAB: will their meaningfulness develop during the learning with each other? We will need to understand further with this direction.

With the above coding and analyzing, we find that:

Meaningfulness matters to the Project, and it functions not alone or isolated to the Project, but in a way that is “Project”-relevant, collective, and potentially developing.

As the “Meaningfulness” is an underlying and less frequent code, we rely on the in-depth case study to guide our grounded theory. The “Project”-relevant, collective and developing feature of “Meaningfulness” is useful in guiding directions for our further analysis.

We define

this “Project”-relevant, collective, and potentially developing status of Meaningfulness as “Co-Meaningfulness”.

It is important to note that here, we define Co-Meaningfulness as it is one of our key category which sets up the initial direction of our grounded theory. But it is far from a comprehensive and mature category or concept at this stage. As we develop our grounded theory, we will further investigate the “Project-relevant”, “collective” and “developing” aspects through comparative analysis of more data and coding. But we also argue that it is important to define Co-Meaningfulness here. First, we need a name for this underlying phenomenon, and “Meaningfulness” alone is not sufficient, especially for the “collective” feature. Second, the “Co-Meaningfulness” defines the key focused categories that foreshadow our grounded theory. In the constructivist grounded theory, the researcher iteratively selects key coding as categories, compare them with more data and coding to develop the grounded theory. With this purpose, the “Co-Meaningfulness” is the pivotal category that guides our further analysis

The below illustration shows the theorizing so far:

- Meaningfulness evolves into Co-Meaningfulness: “Co-Meaningfulness” is different from “Meaningfulness”, as it represents the “Project”-relevant, collective and developing aspects of “Meaningfulness”
- Co-Meaningfulness is an emerging pivotal category that connects to different focused codes of CoLAB. Project-relevant connects to the “Project”; Collective Status concerns the meaningfulness dynamics in the group; Potential to Develop reaches to the past experience and its development.

Chapter 7. Co-Meaningfulness and its Trajectories

In the previous chapter, we present the key category of “Co-Meaningfulness”. In this chapter, we will expand this category by an extensive study of the project “Jumping Video”. Unlike in the previous chapter where one case was studied in depth, in Chapter 7 we study all the 6 episodes and generate useful categories and properties from comparing situations in different episodes. This process in grounded theory is called theoretical sampling, as the sampling is directed by certain theoretical and analytical results, which in our case is the emerging category of “Co-Meaningfulness”. The theoretical sampling is important as it will expand the sub-categories and properties of our grounded theory with more comprehensive data and codes.

We base our comparative analysis on the “conversation” and “memo of the conversation”, supplemented by the interviews. The purpose is to generate more categories and properties related to the category of Co-meaningfulness through further grounded theorizing.

7.1 Further Coding for Categorizing Co-Meaningfulness

In this section, we will further code the data across all the Episodes for categorizing “Co-Meaningfulness”. Particularly, we base on the previous foreshadowed direction and try to generate the sub-categories from two perspectives: the “Project-relevant” perspective and the “Collective Status” perspective.

The “Project-relevant” Perspective

The “Project-relevant” Perspective of Co-Meaningfulness means that the Co-Meaningfulness is not independent to the “Project” students are working on. To the contrary it is essentially manifested in its relation to the project. But how do they relate to each other? What sub-categories of process and properties can we generate from the data? These are the questions for this section.

- Implicit and Explicit : How is Meaningfulness Presented

The first code that categorizes the relation between Co-Meaningfulness and the “Project” is the implicit or explicit presentation of meaningfulness. In

some situations, students find it necessary to explicitly state their meaningfulness, in other situations, meaningfulness is implicitly discussed. In both explicit and implicit presentation of meaningfulness, the purpose is to influence the “Project”.

For example, in Episode one, the meaningfulness was not explicitly presented, but all the group were discussing on the feasibility issue. There was an unspoken consensus on that meaningfulness. It did not create any communication problems, as the group more or less agreed on that implicit meaningfulness. Or they did not agree but didn’t bother to explicitly state that.

Episode 1. The Selfi Stick (Line 1-28)	
There are almost no explicit meaningfulness communication. But there is some hint of implicit meaningfulness. 1. Most conversation is around the feasibility issue of the project. There seems to be a consensus on that.	implicit meaningfulness

(from A3.1 Memo of Conversation)

However, in Episode 2, Xid and Ming started to make more explicit on the meaningfulness. As they sense the other did not understand well enough and the communication on the “Project” level is not sufficient. In the following memo, the status of the Co-Meaningfulness was described as a “tug a war”, the two students were arguing back and forth on their respective meaningfulness. They both tried hard to clarify their meaningfulness in the “war”, aiming to drag the “Project” to their side of meaningfulness.

Episode 2. New Proposition (Line 30-60)	
This part, in the beginning, I wanted to describe as a conversation of “meaningfulness”. But then I changed my mind, as conversation doesn’t say much about their will to drag the Project to their preferred direction. It is more like “tug a war” of “meaningfulness”. Xid and Ming try to drag back and forth. It seems in this part, no one wins the war. But during the war, both of them tried to explain more clearly their intention and meaningfulness.	“tug a war” of meaningfulness back and forth clarify meaningfulness

(from A3.1 Memo of Conversation)

The Episode 3 saw a stuck situation, where the Project suspended grow as the Co-Meaningfulness was in a very entangled status. Unlike in the previous episode, where students were at least trying to clarify the meaningfulness, in Episode 3, the progress in clarifying meaningfulness was slow. The Meaningfulness was unable to be present clearly so as to influence the Project.

Episode 3. Getting Stuck (Line 61-170)	
It is a pity that even at this point, when Xid talks about “quality does not matter”, Li and Xid couldn’t dig deeper about their different meaningfulness that drag the project to different direction. Li answers “Li: it looks complicated. Some one can take the job”(L 105), which goes back to his old statement, without progress in clarify his meaningfulness.	missing opportunity to dig deeper the meaningfulness little progress in clarifying meaningfulness

(from A3.1 Memo of Conversation)

- **Active and Passive: How do learners participate**

The Meaningfulness is inherently related to students’ motivation in the project. If a student perceives the “Project” to be meaningful, he or she will very probably actively participate in the “Project” making. On the other hand, if the student does not think his or her meaningfulness has something to do with the current, he or she might just stay passive in the “Project”.

In the first Episode, we can see Ming actively participated in the “Project” construction while Xid was relatively passive, which is the opposite in the second Episode.

Episode 1. The Selfi Stick (Line 1-28)	
The major discussion here is the implementation problem of the selfie stick. From the post-interview we know this selfie stick is largely an idea of Ming’s interests. Ming seems to be very interested in the specific idea alone.	Actively involved in the Project

(from A3.1 Memo of Conversation)

Episode 2. New Proposition (Line 30-60)	
Xid was constantly proposing ideas in the first part, she is now the active one.	Active and passive

(from A3.1 Memo of Conversation)

The same situation appeared in the Episode 4, where Ming was not actively involved especially at the meaningfulness level.

Episode 4. Mutual Understanding (Line. 171-231)	
in the above complaint, Xid indicated Ming only understands superficially the meaning of Xid. very directly can be interpreted as the implementation level. Only making efforts in the implementation level means Ming did not actively contribute to the ideas at the level of meaningfulness.	inactive participation
Both the lack of concrete idea and the intention to work out the technology makes Ming inactive in the work.	inactive participation

(from A3.1 Memo of Conversation)

However, in Episode 5, we saw a big turn of attitude. Because the group was quite successful in working out the concrete idea in their prototyping session. All of them seemed to be very active in the “Project” making.

Episode 5. Going outside (Line, 232 - 273)	
The Episode 5 documented the discussion right after their prototyping session outside in the campus. The whole conversation was in a fast pace, everyone was talking fast and continuously, giving response instantly. Everyone was excited and active. They know they have made something interesting and meaningful.	active participation

(from A3.1 Memo of Conversation)

- **Effective: How well is “Meaningfulness” connected to the “Project”**

Even students wants to clary “meaningfulness” in the explicit way, there is an issue of effectiveness. The effectiveness of connecting their “Meaningfulness” to the “Project” level is an important feature of Co-Meaningfulness.

Effective Learner can present well their meaningfulness, and more importantly propose proper “Project” ideas that demonstrate its relation with meaningfulness.

In the Episode 3, we see a situation where Li and Ming failed to connect their meaningfulness to the new “scenario” . Although the purpose of Xid's example of “rollerstaker” was to connect her meaningfulness of “associating movements” to a new scenario that Li might understand, but it apparently did not work. It is partially because Xid's example and her way to connect is not good enough, and partially because Li did not receive it and understand it .

Episode 3. Getting Stuck (Line 61-170)	
Xid tried to fix the problem by proposing new scenarios: "rollers taker", but that didn't work, because Li still did not think about the fun side. They tried to resolve the problem by working out the specific details, that did not work either. it makes their project get stuck	new scenario failing to connect meaningfulness:

(from A3.1 Memo of Conversation)

One of the biggest problems of Episode 3 is that Li kept rejecting Xid and Ming's proposition by only providing very simple rationale - he felt the “Project” was complicated, as I wrote in the Memo:

“He mentioned five times about complicated and nearly every time he did not give rationale to back up his statement. Therefore It is hard for the team member to capture and really incorporate this “complicated” meaningfulness behind” (A3.1 Memo of Conversation)

Li presented a lack in effectively presenting his meaningfulness, or the receive and understand other’s meaningfulness.

Episode 3. Getting Stuck (Line 61-170)	

There seemed to be a barrier that stopped Li's meaningfulness from entering the discussion. He tried to repeat about the feeling of complicated, but the lack of examples, and lack of elaboration makes it very different to propose new project ideas that can represent the meaningfulness. Or to combine the meaningfulness. ... There is no good or wrong meaningfulness, every meaningfulness might have potential. But there is meaningfulness well incorporated to the group and to the project, and meaningfulness standing alone inside someone's head and refuse to connect in an easily understandable way. This first part of this episode (L.60-100) features the later status. It is largely because Li's constant rejection and not being able to understand the other meaningfulness at the same time not being able to explain his own meaningfulness. He mentioned five times about complicated and nearly every time he did not give rationale to back up his statement. Therefore It is hard for the team member to capture and really incorporate this "complicated" meaningfulness behind.	disconnecting meaningfulness from entering Project meaningfulness disconnected from project or group not giving rationale

(from A3.1 Memo of Conversation)

Episode 3. Getting Stuck (Line 61-170)	
Xid tried several times to explain herself by giving examples, and to argue on the rationale, and Ming also tried to work out the detail and supported Xid's meaningfulness. But their attempt did not seem to evoke the echo of Li in empathizing the meaningfulness of "fun interaction".	project fail to present meaningfulness

(from A3.1 Memo of Conversation)

In Episode 6, Ke, as the mentor, presented his effective skills in connecting the meaningfulness to the Project. This was also one of Xid's most impressive learning she mentioned in her interview.

Episode 6. The big fight (Line. 275-443)	
They finally agree partially because Ke is mentor and his word has more authority. But also because he used several different examples to back up his opinion. And he was able to point out the key inconsistency in R's argument. The meaningfulness was well presented and manage to make everyone back to a lined up situation.	good persuasion meaningfulness successfully influence "project"

(from A3.1 Memo of Conversation)

- **Interactive: What types of Interaction Between Meaningfulness and "Project"**

By comparing different Episodes, we can see different ways of interaction between Meaningfulness and "Project" happens, which is a sign of their connection.

The first examples happened in Episode 1. In defending the Project, Ming put forward a new meaningfulness - the feeling of artistic to justify one of his propositions.

Episode 1. The Selfi Stick (Line 1-28)	
2. Ming was very active in defending and creating meaningfulness for the project. When they face the problem of light being in the picture. His first reaction was to ignore. But when Ren insisted on the problem, he propose to make a frame for the light so that it looks artistic. This proposition does not directly solve the problem but accepting the problem and reuse the problem to add new dimension of meaningfulness. - Introducing new meaningfulness to <i>justify a proposition</i> to the "Project".	Project -> new meaningfulness ->justify Project

(from A3.1 Memo of Conversation)

The second interaction we want to exemplify appeared in Episode 2. In this example, Xid tried to combine her meaningfulness with Ming's meaningfulness with a "Project" function "spot light" and colorful. This is a combination of meaningfulness that potentially change the Co-Meaningfulness as well as the "Project"

Episode 2. New Proposition (Line 30-60)	
At the end of the conversation, Xid started to combine. Xid propose spot light and colorful, It is in her mind part of the experience but also proposed because Ming demand specific effect. This is an example of meaningfulness communication change the collective status of meaningfulness and then change the Project	combine "meaningfulness" collective meaningfulness change -> project change

(from A3.1 Memo of Conversation)

Not all interaction has positive result. In Episode 4, we see an interaction that decouples Co-meaningfulness and "Project". In this example, Ming tries to compromise both his and Xid's meaningfulness and their connection to the "Project". He thought working out the specific technical part is enough, and they can just leave the divergence of meaningfulness. But this action of compromising was criticised in his reflection :

"Another lesson I learned from this workshop is to keep communicating with our group members. Otherwise, we will probably diverge into two directions very far before we notice." (see, A2.1)

Episode 4. Mutual Understanding (Line. 171-231)	
"Ming: I think it is not very necessary to think about its objective, be it practical application or having fun. Because we express the idea through the same implementation" M started to compromise and think that they can put aside the disagreement on the objective, and the meaningfulness behind, and just focus on the implementation. This is a compromising attitude, weakening their meaningfulness and its influence on the project. in the post-interview, Ming opposed to this attitude. by saying: "Another lesson I learned from this workshop is to keep communicating with our group members. Otherwise,	compromising meaningfulness avoiding further exchange

we will probably diverge into two directions very far before we notice. ” (see, A2.1)	

(from A3.1 Memo of Conversation)

In Episode 5. when the group came back from the prototyping, they brought very good effect. Ke was very excited and immediately connect the project to his other meaningfulness and forgot about his previous meaningfulness of “powerfulness”. This is an example of “Project” raising new meaningfulness.

Episode 5. Going outside (Line, 232 - 273)	
So actually he did not think it is absolutely necessary to attach every meaningfulness, the fun and imagination of the effect itself evoke his other meaningfulness which is already enough to be very active and propose ideas - e.g. “servo”	Effect raising new meaningfulness

(from A3.1 Memo of Conversation)

The “Collective Status” Perspective

- Conflicting

The first status of “Collective Meaningfulness” we observe is a conflicting meaningfulness, when the meaningfulness students hold easily drag the “Project” to divergent or even opposite directions.

In Episode 2, as we have already studied in Chapter 11, Xid held the meaningfulness of “associating movement as interaction experience” and Ming held the meaningfulness of “specific effect”. They argue for quite a long time before they can finally understand each other and started to look for combined solutions. In the process, their meaningfulness, collectively, present a conflicting status. The same happened to the following episode 3 and 6. In Episode 3, Li was focusing on the practicality whereas Xid focuses on the “having fun”, “new interaction experience”, which is not so practical and useful. In Episode 6, the situation was similar.

Episode 2. New Proposition (Line 30-60)	
The misunderstanding from L42 started as Ming did not really understand enough Xid's underlying meaningfulness. Ming was focusing on the specific effect, which Xid believe does not even matter. What Xid believes as important is the association of movements – subject can control the lighting and camera with their movement and supplemented with a playfulness feeling.	meaningfulness not align

(from A3.1 Memo of Conversation)

Episode 3. Getting Stuck (Line 61-170)	
But Li started from a very practical perspective. His meaningfulness is very centered on the practicality side (e.g. he gave an example of capturing wild animals, a very practical application that looks like Xid's idea). This practicality meaningfulness is very different from Xid's meaningfulness of “fun (even crazy) experience”.	Meaningfulness - practical different meaningfulness

(from A3.1 Memo of Conversation)

Episode 6. The big fight (Line. 275-443)	

The last episode is a big fight on the naming. Xid wants to call in “You jump I jump” while Ren wants to call it “jumping video” The rationale for Xid is that “jumping video” is not fun, does not present her key consideration of “association”, But Ren did not seem to agree much on that meaningfulness. For her the naming should be easily understandable for users.	divergent meaningfulness not agreeing on meaningfulness

(from A3.1 Memo of Conversation)

In the last example, we see a special case where their meaningfulness posit an opposite direction. Ren believed the name “you jump I jump” was not explicit, and it did not say anything about the Project. But Xid however believe not being straightforward is on the contrary an advantage as it makes people curious. The reason of their opposite interpretation to the same “Project” idea was that they hold an opposite meaningfulness.

Episode 6. The big fight (Line. 275-443)	
For Xid, not being straightforward is on the contrary an advantage. It makes people curious about the content in the video. And people would understand the content after they see the video.	opposite meaningfulness to the same “project” idea

(from A3.1 Memo of Conversation)

- Supporting

In many cases, friendly and supportive meaningfulness is proposed, sometimes by the same participant and sometimes by other participants to support their peers. The supportive meaningfulness create the second status of meaningfulness status.

Episode 2. New Proposition (Line 30-60)	
What Xid believes as important is the association of movements – subject can control the lighting and camera with their movement and supplemented with a playfulness feeling. These two meaningfulness get along as the playfulness	Meaningfulness : association supportive meaningfulness: playfulness

feeling is kind of experience and so is the association.	

(from A3.1 Memo of Conversation)

In episode 6, we see a situation of multiple supportive meaningfulness, which I noted as family meaningfulness in my memo. They are not the same but they do support each other and lead the project to similar direction.

Episode 6. The big fight (Line. 275-443)	
Another disagreement appears when Ke and Ming are arguing if they can use the software to represent the movement of the actual camera. Ming's argument is that the movement of a camera might change the habit of photographer, therefore he might not be so used to the new interaction. besides this point, Ming (together with R) also propose some other practical meaningfulness: e.g. calculating the relative speed, calculating the center of the video "Ming: Or it is contrasting to human nature." (L 375) "Ming: I think there is another point that Joel mentioned, that taking video is a good way to recording the movement(speed) of the subject relative to the earth." (L.382) "Ren: in fact, can it be like this, from technology pov. It can detect the center of the picture, so that if the photo is constructed unbalanced, the camera would move automatically to put the focus center to the real center" (L. 389) "Ren: can that people would understand better the rationale of the design , which is to capture the center of mass of the picture. Because normally people would ask why the camera move according to the movement of the subject. People wouldn't understand what we try to express here. However, if we add the concept of center of mass, then the people standing here, the picture is not balanced, and then the camera would	family meaningfulness meaningfulness practicality useful application not challenging status quo

automatically adjust so that the center of mass is balanced. ” (L. 391)	
But Ke has the opposite opinion. He agrees on Xid's meaningfulness , that the association is important. and from his point of view, the two conflicts are two sides of one problem - what is the actual essence of the project. holding the same meaningfulness, Xid also do not think the challenge of Ming is a big problem, as the purpose is to challenge the current photographing and make new ways of photographing. Ke and Xid's meaningfulness can be indicated from the following statement. “Xid: I don’t think it’s a problem. There’s a lot of anti-instinct design.” “Xid: and this design . I really haven’t thought about its practical value. Or the practical details. Do you need to go that deep? Considering its value ” “Ke: OK, I think the point is to make people uncomfortable.”	family meaningfulness meaningfulness association, new experience uncomfortable design(challenging the status quo)

(from A3.1 Memo of Conversation)

- **Coherent**

The last situation is when the meaningfulness is aligned in the group. In the coherent status, the group usually agree to each other in the meaningfulness and can communicate on the “Project” level more easily.

Episode 5. Going outside (Line, 232 - 273)	
The consensus in the group is that this effect did make sense. it was result of Xid's original idea plus inspiration from the accident plus going out and trying out. In the final effect we did see a sense of “fun” therefore Xid successful realized her part of meaningfulness. At the same time the effect is very specific, so Ming was also quite excited about it.	agreed meaningfulness-fun
Nevertheless, for Ren it is still a “movie with fun”. So fun is an accepted meaningfulness to Ren.	accepting meaningfulness - fun

(from A3.1 Memo of Conversation)

In this section, we make a comprehensive comparative analysis across the different episodes and generate a set of sub-categories in relation to the “Project-relevant” and “Collective Status” perspectives of “Co-Meaningfulness”. The set of sub-categories give us clue on the different status of “Co-Meaningfulness” and its influence on the socio-cognitive process.

The “Project-relevant” Perspective	The “Collective Status” Perspective
Implicit and Explicit : How is Meaningfulness Presented	Conflicting
Active and Passive : How do Learners Participate	Supporting

Effective : How well is Meaningfulness connected to “Project”	Coherent
Interactive : What types of Interactions between Meaningfulness and “Project”	

Table 7.1. Sub-categories of Co-Meaningfulness

7.2 The Co-Meaningfulness Quadrant Map

In the previous section, we generate a few sub-categories of Co-Meaningfulness concerning the project-relative and collective perspectives of Co-Meaningfulness. In this section, we will generate two key properties of “Co-Meaningfulness” based on the sub-categories we have: the Project-Meaningfulness Intensity (P-M Intensity) and the Meaningfulness-Meaningfulness Coherence (M-M Coherence). As these two properties are indicators of degrees, we build use a quadrant map with these properties as the two axes, where we can anchor the different stages of CoLAB process and make a visual presentation of the Co-Meaningfulness development in CoLAB. The purpose of this step is to demonstrate a visualized tool to researchers to compare different process in CoLAB, and to provide practitioners an available and easy tool for reflecting their practice.

Project-Meaningfulness Intensity (P-M Intensity) and

Meaningfulness-Meaningfulness Coherence (M-M Coherence)

We name the first key property “Project-Meaningfulness Intensity” or “P-M Intensity”, by which we indicate how intensive the “Co-Meaningfulness” and the “Project” mutually influence. It is generated to summarize the degree related to sub-categories of the “Project-relevant” Perspective, i.e “implicit and explicit”, “active and passive”, “effective” and “interactive”. The “Intensity” provides a degree of the intensity of between the “Project” and “Meaningfulness” in the CoLAB process.

To determine the P-M Intensity, one needs to examine the different sub-categories holistically. Are their Co-meaningfulness well-presented or perceived? Do learners actively participate? Does their Meaningfulness has the power to effectively drive the “Project”? Does the “Project” effectively reinforce/challenge/renew the Co-meaningfulness and grow? The “Intensity” property summarizes the degree to which the “Co-Meaningfulness” relates to

the “Project”. And it is related to all the properties we develop in the “Project-relevant” perspective.

As we define “Co-Meaningfulness” as a collective status, therefore “P-M Intensity” also means the general P-M Intensity level of the group. Therefore if everyone is contributing their meaningfulness actively, their P-M Intensity of Co-Meaningfulness is larger than in situations where only one member pushes his or her own meaningfulness.

The “P-M Intensity” is a qualitative degree rather than a quantifiable one. We generate this property from qualitatively comparing different learning situations but not from quantitative measuring. In the scope of this thesis, we cannot provide any quantifiable method for the property, because our data and method do not support such a study, but as the property is interpreted as a degree, it has the potential to be developed into a quantifiable variable, as we will discuss in the chapter CONCLUSIONS.3.

As a degree or a grade, it makes sense to compare the different episodes and argue how the group proceed as their project progresses: if their Co-Meaningfulness becomes more well communicated or is it becoming more alienated to their “Project” . And these changes are qualitatively comparable with our coding and memo writing, as we did and presented in this research. The detailed comparison and grade of “Jumping Video” will be presented in later in this chapter.

The property of “P-M Intensity” is an indicator for all the sub-categories understand the “Project-relevant” perspective: namely the “implicit and explicit”, “active and passive”, “effective” and “interactive”. But that does not mean “P-M Intensity” is a replacement to the sub-categories, but that it is an extra property generated from them with further analytical purposes. We will keep the other properties to maintain a more comprehensive set of properties.

The property of Meaningfulness-Meaningfulness Coherence (M-M Coherence), generated from the “Collective Status” feature, means how coherent different meaningfulness relate to each other. It provides a degree by which we indicate the coherence of “Meaningfulness” in the process. For example, the “conflicting” state of Co-Meaningfulness indicates a low level of M-M Coherence, “supporting” means a medium level, and “Coherent” state implies a high degree of M-M coherence.

Again, The M-M Coherence is a property that we generate from qualitative comparing and analyzing the different states of the collaborative learning. It is not yet a quantifiable property for measuring. To obtain the degree of M-M Coherence, one needs to qualitatively compare different situations through

observing, coding, and analyzing, as we illustrated in the chapter 7.1. The researcher is also the research tool for determining the “degree” of the properties, based on the structured process of grounded theory. As in many cases, “Meaningfulness” is tacit, the research will need to gain a deep understanding of the context and nuances of the real-world practice.

The Co-Meaningfulness Quadrant Map

We combine the “P-M Intensity” and “M-M Coherence”, the two degree by which we measure the Co-Meaningfulness, and generate the **Co-Meaningfulness Quadrant Map**.

We define the y-axis as “P-M Intensity”, so that it presents the intensity level of the Co-Meaningfulness. We use “vigorous” to present higher level of “intensity” and “inert” to present a lower level of “intensity”. The upper quadrants present more “vigorous” Co-Meaningfulness status whereas the lower quadrants present the “inert” status.

The “M-M Coherence” is defined as the x-axis. We use “aligning” to present higher level of coherence and “contrasting” for the lower level. The right quadrants are therefore the more “aligning” Co-Meaningfulness status, while the left quadrants are the “contrasting” quadrants.

With the Co-Meaningfulness Quadrant Map, we can quickly generate four different quadrants (the VA, IA, VC, IC quadrants as shown below Fig. 7.1) in which we can locate the Co-Meaningfulness of different status. .



Figure 7.1 Co-Meaningfulness Quadrant Map

- **Vigorous-Aligning (VA) Co-Meaningfulness**

VA Co-Meaningfulness status is very favorable in CoLAB learning. It is however hard to achieve because everyone has different meaningfulness. When a group reaches vigorous and aligning Co-Meaningfulness, it means that the team has been well communicated and filled their disciplinary gaps, and has willingly agreed on the "Project". This state can mark an ideal CoLAB learning.

- **Inert-Aligning (IA) Co-Meaningfulness**

IA Co-Meaningfulness often appears when part of the team compromises or becomes inactive in realizing their meaningfulness. The team needs to move on, and some of the members choose to compromise or become inactive to make an aligning Co-Meaningfulness. But this Co-Meaningfulness is not stable, and if this state keeps to the end of the project, some of the members will not learn as much as they will in a VA Co-Meaningfulness.

- **Vigorous-Contrasting (VC) Co-Meaningfulness**

VC Co-Meaningfulness status often marks arguing explicitly on the meaningfulness. This state is very hard for a team to progress their "Project" since the team does not agree on what is meaningful and they are motivated to fight for their different meaningfulness. Although this state brings challenges for progressing "Project", it can help the team to communicate their deep understanding of their project. Normally this kind of communication goes beyond the "Project" level and to the core of Meaningfulness.

- **Inert-Contrasting (IC) Co-Meaningfulness**

IC Co-Meaningfulness is the most difficult status. It means the group cannot find a way to agree and is not energetic enough to progress their "Project" because their meaningfulness is weak or they don't have enough skill to realize their meaningfulness in the "Project". This state usually marks a failure and need to be mentored.

The Co-Meaningfulness Trajectory

In the previous section, we generate a new set of properties by emphasizing on the comparison of the degree of "P-M Intensity" and "M/M Coherent" of different episodes. These properties are featured by a quadrant map. In this section, we will apply the quadrant map and analyze the different episodes of

“Jumping Video”. We present the Co-Meaningfulness Trajectory of “Jumping Video” in the map.

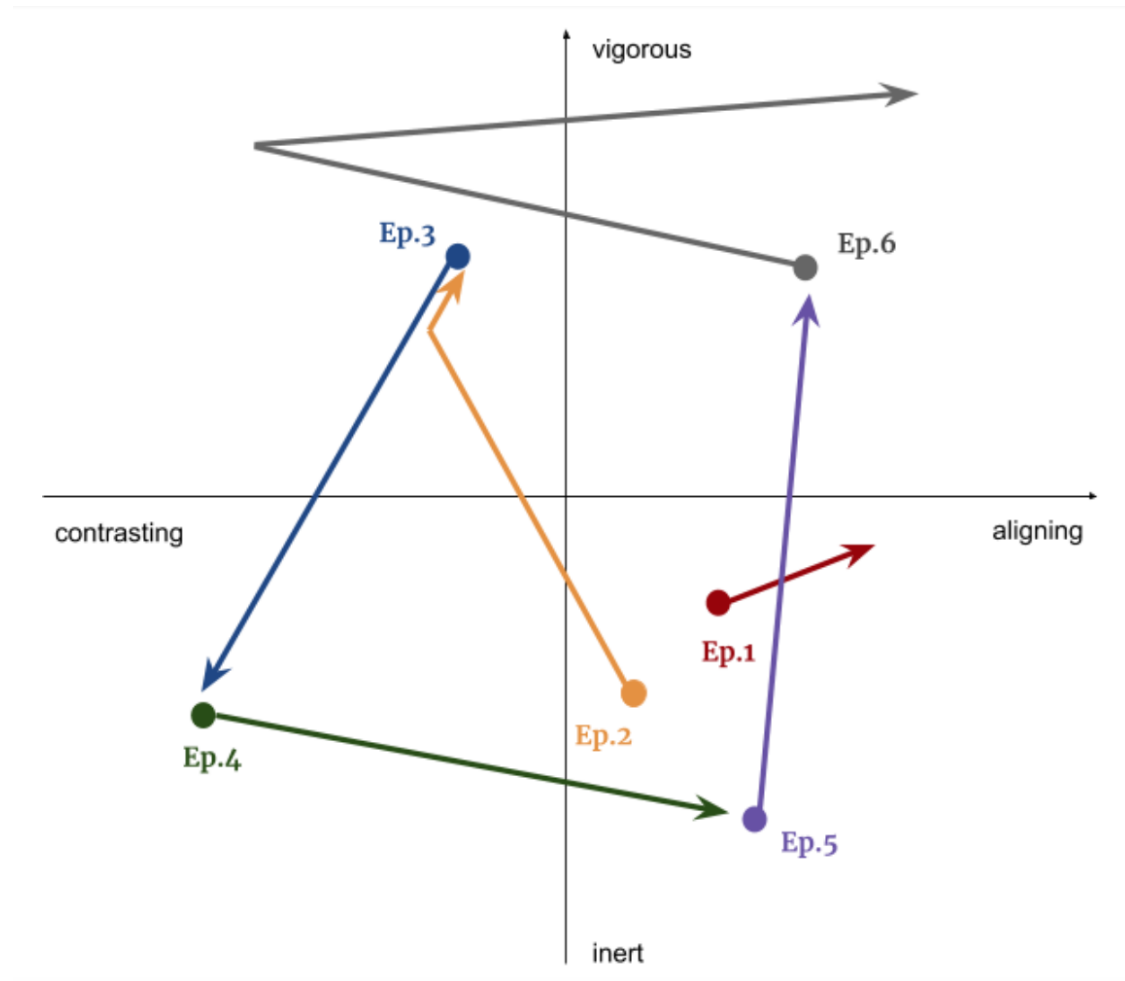


Figure. 7.2 Co-Meaningfulness Trajectories in “Jumping Video”

In the trajectory, we illustrate each episode and their process. Every episode starts with a dot and followed by arrowed lines indicating where the Co-Meaningfulness heads. The positions of each start, end, and turn are carefully considered by constant comparison of different status of the episodes.

Ep.	Description	Quadrants
1	The team starts to work on a project about selfie stick. The Co-Meaningfulness is aligning (on the feasibility), but only Ming is actively engaged. After a discussion on how to implement, the group becomes a little more aligning on the meaningfulness and more active, but the states end as they find out their idea cannot meet the workshop requirement.	IA

2	The episode started as Xid propose to make a camera that automatically take pictures when it senses a special movement of subjects. In the beginning only Xid was actively engaging. But soon Ming disagree on the meaningfulness and they started to argue explicitly, with Xid focusing on the association and interaction while Ming focusing on the specific effect. The explicit argue makes the Co-Meaningfulness moving to the VC quadrant. At the end, they were able to communicate well and agree as Xid propose a “Project” idea to combine. The line has a small turn towards VA.	IA->VC
3	The episode starts with Li's participation. It worsen the situation because Li constantly passively disagree on Xid's meaningfulness. They hold different meaningfulness but they were not able to communicate well actively. The meaningfulness cannot contribute to the “Project”. The Episode saw a sharp decline from VC to IC	VC->IC
4	In Episode 4, the “intensity” problem does not improve. Students participate inactively. They try to communicate on the meaningfulness but the effect was not very well. Ming focused on the technical details, but mentor Ke persuade him that the idea was more important. therefore Ming compromised his meaningfulness, and they agree to go out and try the prototype. In this episode, the group grow coherence of the Co-Meaningfulness by trying to understand mutually each other's work, but at the price of compromising some meaningfulness. The trajectory moves from IC to IA.	IC->IA
5	The Episode 5 saw a radical increase of both “intensity” and “coherence” when they discovered a very good effect in the Project. The active participation and constant applying meaningfulness to create Project idea prove this change. The group reached a small cliMatt.	IA->VA

6	In the last episode, Xid and Ren had a very fierce argument on the name, and this argument reflect a strong contrasting meaningfulness as well as their intention to influence the project with respective meaningfulness. The contrasting co-meaningfulness did not appear in the previous episodes but was evoked by the naming incidence. The group were about to fall apart and mentor Ke decided to interfere by explicitly pointing out the different meaningfulness and compare. The comparison successfully persuaded the group and helped them to reach a more aligning and vigorous status.	VA->VC->V A

Table 7.2 The Co-Meaningfulness status and quadrant by episode

The trajectory is a visual analytical tool that helps us identify key moments of the process. In the example of “Jumping Video” we can see how the group has changed from episode to episode and identify the problems and good practices. It is an analytical tool for researchers and also a reflexive tool for practitioner. The properties and transformation of process is directly seen and easily documented.

In this section, we present how we can locate the different states of CoLAB and generate the Co-Meaningfulness trajectory. The generation is followed by a coding and categorizing method, especially using our sub-categories of the “implicit and explicit”, “active and passive”, “effective” and “interactive” to determine the P-M Intensity and the “coherent” “supporting” and “conflicting” to determine the M-M Coherence.

But we also note here that the Co-Meaningfulness trajectory is not complete here and remains to be developed in the following chapters. After we analyze CoLAB in the socio-cultural perspective in the following chapters, we will further develop the tool and guide how to use the tool in chapter 11.

Conclusion of the Grounded Theory of the Socio-cognitive

Perspective

The grounded theory in chapter 6 and 7 makes the following contributions in understanding Co-LAB from the socio-cognitive perspective:

1. It generates a key concept “Co-Meaningfulness” in understanding the cognitive process of CoLAB. The concept is particularly important when

we try to understand the communication difficulties caused by the heterogeneous background of the team.

2. It generates two key properties of “Co-Meaningfulness”: “P-M Intensity” and “M-M Coherence” for comparatively analyzing the different stages of the socio-cognitive process. The quadrant map and the trajectory provide visualization tools that are useful for both researchers to analyze the process and for practitioners to easily reflect the process.

We so far only discuss the socio-cognitive process of the CoLAB largely from an interactionist perspective. But we have not discussed CoLAB from a socio-historical or socio-cultural perspective to relate the process to its social context. We will discuss the socio-cultural aspect of CoLAB in the following chapters in this PART II.

Chapter 8. The Socio-Cultural Perspective of CoLAB and Co-Meaningfulness

8.1 Introduction of the Socio-Cultural Perspective of CoLAB and Co-Meaningfulness

In the previous chapters, we enter the analysis from a socio-cognitive perspective. That means we focus on the interactive conversation between the learners during their CoLAB learning. From the grounded theory on their interaction, we generate the important concept of “Co-Meaningfulness”, which indicates:

“Project”-relevant, collective, and potentially developing status of Meaningfulness

The “Co-Meaningfulness” derived from the socio-cognitive grounded theory helps to analyze the interaction especially the conflicts in the learning. For example, the two properties “M-M Coherence” and “P-M intensity” is useful in understanding the different interaction stages, their trajectories, the key moments and their drives in the interaction.

But we also recognize that only the socio-cognitive perspective is not enough. The interaction and cognitive process does not give enough on who these learners are, why they organize and participate in the new way of learning, what do they bring from the past learning and how do they engage them in the CoLAB, and what impact will the learning has upon the future and the development of the learner. All these issues reach beyond the socio-cognitive interaction per se. From a socio-cultural perspective, learning is not isolated from the learner’s socio-historical experience, nor it is isolated from the socio-cultural context of the learning. There are deeper reasons and motive for the trajectories and turns. Therefore, in the following chapters, we will complete the grounded theory with a special focus on the socio-cultural perspective.

Particularly, we use our key concept “Co-Meaningfulness” as a starting point for our analysis. In the previous analysis, we have encountered several times the socio-cultural perspective of the “Co-Meaningfulness” awaits for further development. The following presents the socio-cultural perspective of “Co-Meaningfulness” before, during and after the learning.

1. “Meaningfulness”

The “Co-Meaningfulness” is generated from the initial coding of “Project” and “Meaningfulness” in the Chapter 6. From the coding and analysis, we understand that the individual “Meaningfulness” plays an important role when each learner communicates and learns, especially when they meet potential challenges.

But what is exactly the “individual Meaningfulness”? How does individual obtain this meaningfulness in the first place and bring it to the learning? We cannot answer these questions by only analyzing the interactions. We need to know who the learners are before, and why do they feel meaningful in certain ways and in what social context. We will need to relate to the socio-cultural aspect of the “meaningfulness”.

2. “Co-Meaningfulness”

In the previous chapters, we understand that the Co-Meaningfulness is potentially developing in the learning process. The “M-M Coherence” and “P-M Intensity” model is a set of properties to present such development from a socio-cognitive perspective.

This development is not isolated from the socio-cultural context as well. We will need to understand how this development is related to the socio-cultural perspective. What is the impact of this new Co-Meaningfulness on learner’s future development, on the learning community and eventually on the socio-cultural context?

As we can see, the concept of “Co-Meaningfulness”, though generated from the socio-cognitive analysis, is however not a concept solely concerned with the interactions. What a learner believes as “meaningful” is essentially related to the learner’s past experience and the social context. The “Meaningfulness” is potentially a key link between the socio-cognitive and socio-cultural understanding of the learning activity. We further develop this perspective of “Co-Meaningfulness” with grounded theory.

We continue to use constructivist grounded theory as our research method. The data we choose is an ethnographic study of a workshop series over one year. We also choose two typical workshops and two projects in the series as the primary data for analyzing the CoLAB process. Data includes notes, memos, voice recordings, formal and informal interviews. The detailed conversation analysis is however not used in the socio-cultural perspective, as our focus is no longer the interaction.

Although the method we use is the similar as the previous chapters, we would like to mention two distinguishable focus of our data sampling in the following chapters. These focuses are reflected in our selection of data and memo writing.

We will focus on activities in relation to the learners' socio-historical experience, instead of just study the interaction per se. The interaction or cognitive operation are seen in a larger picture in the social context. That does not mean, we completely omit the interaction or socio-cognition of the learners. Instead, we take a hybrid perspective, but with a keen eye on the link between the interaction and the social context: the social identity and existence, their socio-historical learning experience, etc..

We will focus on the workshops, as well as relevant extension activities, namely the workshop preparation, workshop recruitment, built-in lectures, informal discussion, recapitulation, etc. These extended activities as well as daily life ethnographies are considered as important parts in the socio-cultural perspective, which can cast light to the learners' learning and living. With this focus, we can better understand the overall context of CoLAB, which is lacking from what we present in the previous chapters.

With a thorough grounded theory analysis, we come to the following analysis results:

- The Basic Pattern of “**Evoking**” and “**Applying**”: Individual Meaningfulness is not purposely created to fit the “Project” at hand, but generated when learners **evoke a (or multiple) socio-historical “Project”** and **apply its socio-cultural “Meaning”** to the current Project. **Evoking Socio-historical “Project”** means the current project evokes the learner’s past experience that has certain relevance to the project at hand. **Applying Socio-cultural “Meaning”** means the learner apply the associated meaning of the evoked experience to the current Project. The basic pattern is ubiquitous in our initial coding. It explains the basic process in which the learner engage their past learning and the attempt to apply their meaning in the current “Project”.
- The Underlying Pattern of “**Prioritizing**”: Choosing what “Project” to evoke and what “Meaning” (and how) to apply is subject to an underlying pattern of “**Prioritizing**”.
 - a) **Multiple potential P/M**: the learner has a large pool of past experience and associated social meaning, much of which might have certain relevance to the project. This pool weaves a P-M network with complex inter-connection and extensional potential.
 - b) **Prioritizing**: Not all “Project” and “Meaning” in the network will be evoked and applied. One might omit some projects and compromise some meaning over others in the network. There is an underlying priority according to which the learner selects to “evoke and apply”.

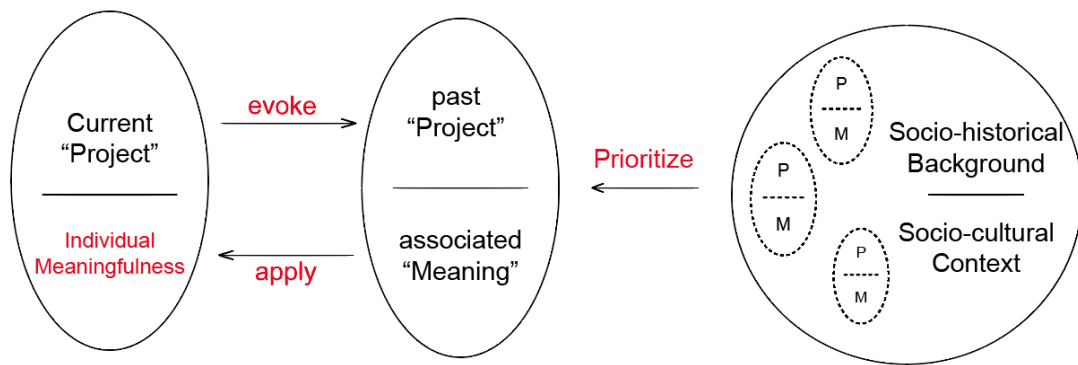


Fig. 8.1 Constructing "individual Meaningfulness" by Evoking, Applying and Prioritizing

- Co-Meaningfulness is then not just a process concerned with "Project" and "Meaning" on the table, but a clashing of different learners' "evoking" "applying" and "prioritizing" process. With focused coding, we are able to conclude a three-level framework of "Co-Meaningfulness" from both the socio-cognitive and socio-cultural perspective (Table V.1). The framework is both a framework of coding for researchers and a practical tool for practitioners with which they can diagnose their CoLAB learning.

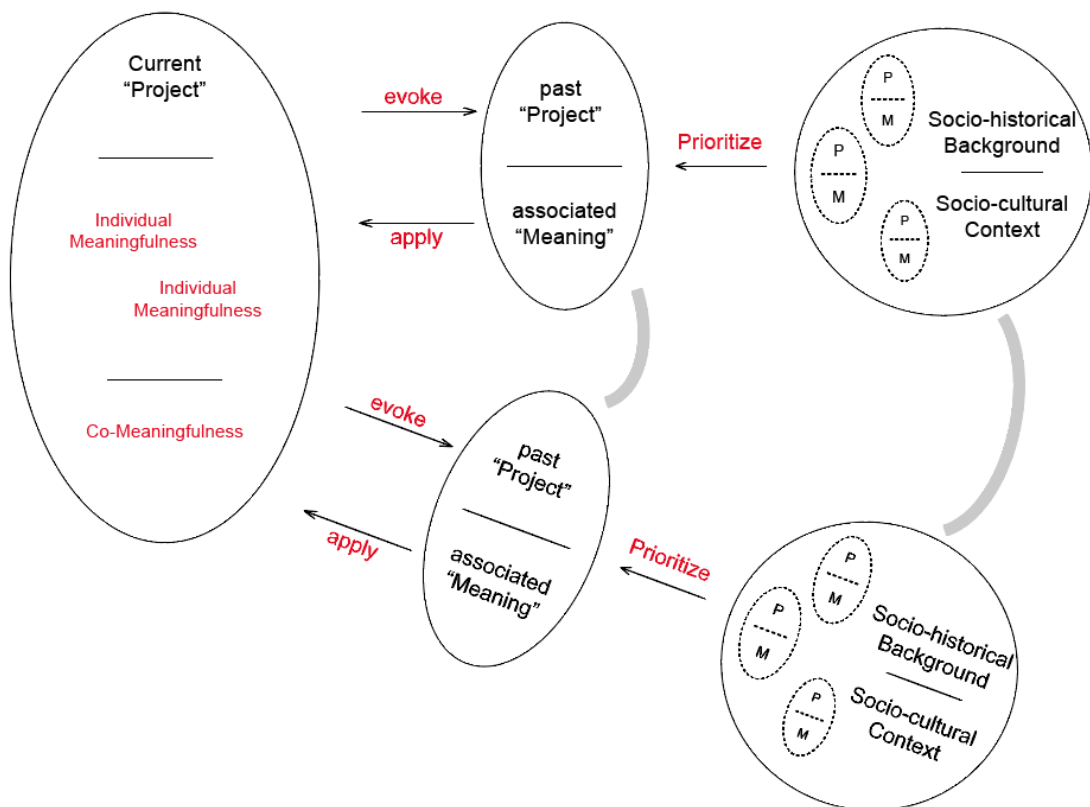


Fig. 8.2 Constructing "Co-Meaningfulness" from multiple Meaningfulness

Levels	P-M Intensity	M-M Coherence
Evoking	1. Does the learner present the evoked project? How well?	
	2. Does the group understand the evoked the project and its relevance to the current Project? How well?	
		3. Does the group agree on the relevance of the evoked project?
Applying	4. Does the learner present the applied meaning? How well does he or she present ?	
	5. Does the group understand the meaning applied and its relevance to the current Project? How well?	
		6. Does the group agree on the relevance of the applied meaning?
Prioritizing	7. Can the learner evoke and apply P/M that he or she prioritize?	
		8. Does the group agree on the prioritizing?

Table 8.1 The three-level framework of Co-Meaningfulness

8.2 Co-lab Bio-design Workshop Series

From chapter 8 on, we will use ethnographic data from a long term observation (19 months) of a series of interdisciplinary workshop : Co-lab bio-design workshops, or Co-lab.

The workshop series were interdisciplinary workshops with different topics of science, and mostly biology and bioengineering, combined with different methods of design. The average Co-lab lasts between 2 and 4 days and involve participants mostly between 20 and 30 years old from in life sciences, art, design, business, and engineering. The workshop is a place where artists, designers, and scientists meet to initiate collaboration, and work together to deliver a project with a tangible output. The purpose of the workshop was to encourage real interdisciplinary collaboration, as the founders put in their manifesto:

“We aggregate designers to learn science. We encourage scientists to value and learn artistic approach and design thinking.” (from Co-lab internal documents)

The community organizing it is physically dispersed around the world, and is mainly based in an NGO that we have been participant observing, together with other partners that change depending on the location and topic of each workshop.

The organizer team summarize their principles of the workshop as:

- “1. Horizontality and diversity: Co-labs are co-organized by participants and mentors together. We encourage diversity of background, gender, and age among the participants to achieve a rich environment.
2. Interdisciplinarity: Co-lab use methodologies, lectures and knowledge that belong to several disciplines. The mentors and organizers make mixed groups of scientists and designers to prepare each of the science and design activities.
3. Openness and documentation: All the works are shared in a CC BY 4.0 license. We know that open source requires more effort than just a good license, so we prepare booklets describing the lectures, workshops, and projects created, and share everything in an open Google Drive repository and on social media.

4. Practicality and experimentation: We prefer activities and outputs that involve the actual doing or experience of something rather than theories or ideas. Making is a media for facilitating interdisciplinarity. We leverage the diversity among participants to promote peer to peer teaching and learning. We are fearless in trying out innovative educational methods and developing our own content based on previous experience.” (from Co-lab internal documents)

I (Ke, the author of this research) have been an active participant observer in the workshop. In most of the workshops, I have participated as a core co-organizer who have contributed designing and organizing part of the workshop. At the same time, I have been documenting the process during workshop preparation, implementation, recapitulation, and informal discussion, etc. I have been living with the core co-organizers, communicating on a daily basis, contributing my knowledge and skill in the workshop series and at the same time keeping observation as an ethnographer.

The workshop idea came out in an informal meeting after the IGEM 2016 student competition between Lina, a designer based in London, and Juanmat, a bioengineer based in Paris. Both have been involved in interdisciplinary projects and thought they lacked a space where life sciences and design could meet in a fair and tangible way. The first workshop was quickly organized in two sessions in the London Biohacker Space and the Faculty of Medicine of Paris Descartes University about the topic of synthetic biology.

Soon, through the student-lead NGO Open Science School based in the Center for Research and Interdisciplinarity of Paris, a self-organized and volunteer community started to gather, and more projects came out to bring co-lab workshops to several locations around the world, in partnerships with both academic institutions (University College London, John Innes Centre in Norwich, University of Cambridge, Design School of Tsinghua University in Beijing, Shenzhen Tsinghua Graduate School, Center for Research and Interdisciplinarity of Paris, Institut Pierre Gilles de Gennes, Ecole Polytechnique Federale de Lausanne) and noninstitutional actors (Makerversity London, London Biohackerspace, Cambridge makerspace, Hackuarius Biohackerspace Lausanne, Institute of Making, Volumes coworking space in Paris).

During the 19 months, 10 editions of co-lab have been organized in different topics depending on the location, partners, funding, and interests of the organizers.

The workshop usually takes 2 to 3 days on a weekend. A typical workshop consists of 4 parts:

Introduction -> Biology -> Design -> Making An Interdisciplinary Project

The **Introduction** part gave context of the general purpose of Co-lab workshop. It was done through a lecture of introducing our ideas and beliefs in interdisciplinarity, and completed by a discussion on general concepts. For example, in the first Co-lab, the topic was about “what exactly everyone perceive interdisciplinarity as it is becoming a buzz word”.

The introduction was followed by some **Biology** section, e.g. a lecture on cell biology and transformation. The purpose of this section is to give designers some context of the biology knowledge that can be used in the later project making.

Then, **Design** sections is held to familiarize the biologists with designerly ways of working. This part was practice based. For example, everyone was given instructions to draw a story based on previous discussions. This narrative approach was taken from one of the organizer’s design class.

The last and most important part was the **Making An Interdisciplinary Project**, where participants were asked to form an interdisciplinary group and make their own project during the last two days, with whatever they learned in the first day.

	Friday	Saturday	Sunday
10am - 11am		Make an interdisciplinary project	Make an interdisciplinary project
11am- 12pm			
1pm - 2pm		Lunch	Lunch
2pm- 3pm	Introduction	Make an interdisciplinary project	How to write and present a scientific project
3pm - 4pm			Break
4pm - 5pm	Science workshop: cell biology and transformation		Present and document your project
5pm- 6pm			
6pm - 7pm	Narrative workshop	Science workshop: in silico cloning and protein 3D structure	Dinner
7pm - end			

Table 8.3 Typical schedule for a Co-lab workshop

The ethnographic fieldnotes and code of two co-lab projects the DNAish food and the Chrome-air attack (see Appendix B and C) will be constantly referred in the later analysis, therefore it is recommended to read the two examples before reading the analysis.

8.3 Core organizers and the Learning Community

The core team carrying the project is a combination of scientists and designers experienced in working with both communities and facilitating the communication. Among them, the three founders play the most important role:

Juanmat: PhD candidate in Biophysics, MSc Education,.

Lina: designer, educator, interdisciplinary mediator.

Ke: Ph.D candidate in anthropology, designer, educator.

Juanmat and Lina, two of the main organizers of Co-lab workshops, met for the first time in the iGEM competition in Boston⁹ in the summer of 2015. Lina was at that time a member of London Biohackspace iGEM team, working on a toolkit for DIY beer. Juanmat also joined the 2015 iGEM Competition in the Paris Bettencourt team as a mentor, working on synthetic probiotics.

When Lina and Juanmat met, Lina was quite upset about one incidence in the competition. She met someone on site and was just about to explain their project, when the scientist expressed that he wanted to talk to the “scientist” in the team. Although Lina was a designer, she did learn and contribute a lot to biology part in the team. She was more than an affiliated designer who just “do the drawing”, and she expected to be treated just as her scientist peers. But the stereotype of that scientist made her feel that even in a competition promoting the interdisciplinary collaboration, the gap was still there.

Juanmat told Lina they should do something. Juanmat, as a scientist, however had a good understanding of the design side. He occasionally does painting and used to exhibit his work in his town. He likes design and has many experiences working with designers. In the year 2014, Juanmat’s team won the best supporting art and design award in iGEM. He had enjoyed working with designers.

Hearing the complaints of Lina, Juanmat believed that gap existed as designers and scientists do not know each other very well, and they might be able to start workshops that promote REAL interaction between the two communities. Lina and Juanmat, with great passion, decided to work on that when they came back to Europe.

They did not stop on the words. The first thing they did was summarizing what they wanted to do, and put it on a google doc they named “idea generation”, which also presented their very passionate motivation :

⁹ iGEM, see chapter 1, for reference on this competition

“Our workshop is a place where artists, designers, and scientists meet to initiate collaboration. We aggregate designers to learn biology. We encourage scientists to value and learn artistic approach. We bring artists, designers, and scientists together to explore the possibilities of biological design.

The goal of the project is to foster the creation of truly interdisciplinary projects around synthetic biology.

Interdisciplinarity is a tool to solve complex problems that are beyond the reach of any discipline alone. To be able to do this, many soft-skills need to be developed. University and school often forgets about some of them. However, we believe that they are central to face the challenges of this emerging new world: conceptualization, inter-cultural communication, project-based learning, adaptation, and willingness to learn. conflict is the source of creativity.

We also believe that $1 + 1$ is not equals 2, but sums much more. Being able to exchange knowledge is the most valuable tool that a community can have. Being able to use the skills that we have learned from our field in another discipline makes us valuable.”

Co-Lab in total had more than 300 participants in all of the workshops, among which there are 15 mentors and participants actively involved in organizing and iterating the workshops, forming the core team. Co-Lab has received great support from early-career scholars as advisors, who help to host several workshops, as well as others from international institutions.

Co-Lab relies on constantly evolving itself according to its topic and methods each time. When Co-lab evolves, it invites a new group of participants, normally experts in the new topic, to the core organizing team, or the **participating organizers**. The new group brings in not only new knowledge, new ways of thinking, that helps connecting the co-lab spirit to a new group of audiences. Participants in co-lab communities are often young scientists, designers, engineers, artists, businesspeople, who share openness in interdisciplinarity and collaboration, or life-long learners who eagers to explore in a new field. Access to the project are open and well-documented. Co-lab especially encourages participants to adapt their co-lab projects to other uses.

In the following chapters, we largely use the data collected from the long term ethnographic observation. In our long term observation, we receive and follow the research ethics guidance from the Center for Research and Interdisciplinarity for conducting this research. Before any data collection, we orally inquire for consent of our participants and inform their use of data, and received their consent before we conduct the data collection. For analyzing

the process, we purposively sampled two projects in detail. Our ethnography (in APPENDIX B.C) is based on our fieldnotes, voice recording and interviews, all collected under the research ethics guidance from the Center for Research and Interdisciplinarity(All names are pseudonyms).

Chapter 9. “Evoking” and “Applying”: the Basic Pattern

In this chapter, we will use grounded theory to analyze CoLAB from the socio-historic and socio-cultural perspective. We will see what role past experiences play in the learning, how they are brought in and how they became a part of the collective project space, and how they construct the learner’s meaningfulness and the group’s Co-Meaningfulness.

With these questions in mind, we conduct initial and focused coding and summarize two typical patterns of process that underpins the “Meaningfulness” concept, which are **Evoking Socio-historical Project** and **Applying Socio-cultural Meaning**.

Evoking Socio-historical Project means the current project evokes the learner’s past experience that has certain relevance to the project at hand. **Applying Socio-cultural “Meaning”** means the learner apply the associated meaning of the evoked experience to the current Project.

The Applied Meaning then becomes (at least part of) his or her recognition why the project at hand is meaningful. The meaningfulness is not created, but associated with the socio-historical “Project” and socio-cultural “Meaning” through the basic pattern of “Evoking” and “Applying”.

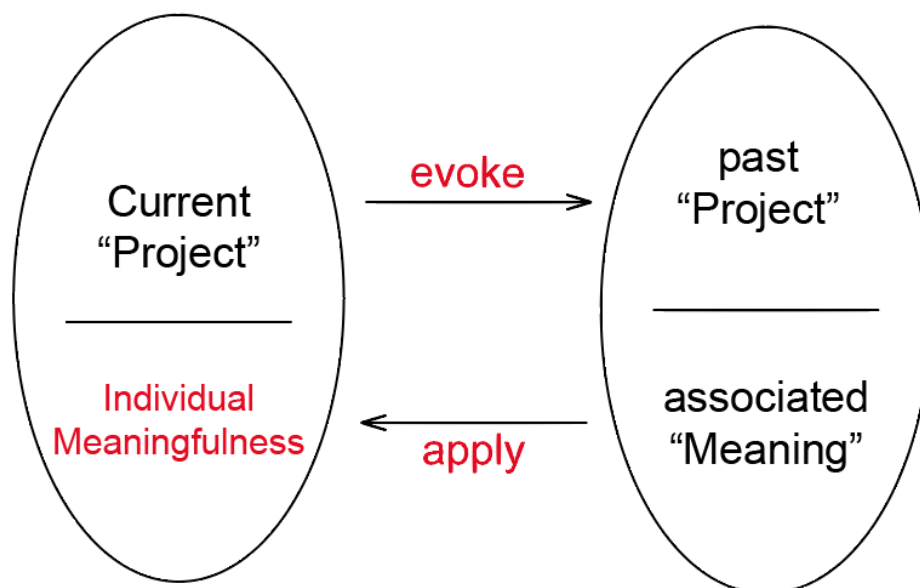


Fig. 9.1 Basic pattern of “meaningfulness”: Evoking and applying

Upon abstracting the two key codes from the initial coding, we are able to summarize the typical pattern of socio-historical past experience, and its relation to the **“Meaningfulness”** that the meaningfulness is not created specifically for the project at hand, but generated through a process we call “evoking and applying”. Evoking means that the learner evoke a socio-historical experience that has certain relevance to the current Project while applying means

9.1 Evoking Socio-historical Project

In analyzing the socio-historical experience and its relation to the current learning, we use grounded theory to study how learners engage their past experience.

The initial codes such as “Recalling past experience”, “Recalling relevant past knowledge” (Appendix B1 Chris’s background) “Recalling project example” (Appendix B3 What’s interdisciplinarity) “Referring to real lab experience” (Appendix B2 Does Science Communication Need Emotion), etc. have evidently demonstrate that past experience and projects are commonly engaged in the collaborative learning. We extract the focused code **“Evoking Socio-historical Project”** to summarize the process where **the current project evokes the learner’s past project or experience with certain relevance to the project at hand.**

The gerund “Evoking” indicates the current discussion is seen as a cue for individual learners to evoke a relevant “Project” they made, participated in, observed, saw, or heard. This evoked Project was part of their socio-historical experience, obtained in formal or informal learning. It can be a previous student project, an exemplary project in competition, an example in class, or even a social event, a YouTube video, a movie, a piece of news, etc.

Calling it a “Project” is sometimes not exactly accurate. Sometimes learners will evoke the “Project” as a whole in the collaborative learning. But in other cases, learners may just reveal and engage a specific component of a project in the collaborative learning. Therefore it is present as a partial project, e.g. a scenario, a specific effect, a function, etc (e.g. Fig. 6.1). However, in order to keep the simplicity and consistency of the focused codes, we will hereafter use only **“Evoking Socio-historical Project” (or the short version “Evoking”)** to refer to the above two cases.

The following (Table 9.1) is one example taken from the second Co-lab when Juanmat and Matt are discussing on “science communication” in the workshop, where multiple “Evoking” took place.

Just before Lina starts the workshop, she share with the group a movie she found very inspiring. It is a movie called My American Uncle(Mon oncle d'Amérique) written by a French scientist Henri Laborit. To Lina, the movie constantly compare mice experiments to societal relationship which explains the science, especially neuro science in a way that is related to the society. <i>“The meaning behind the movie is “big” – concerning the science of emotion and how it affect our inner organs, which compares to the social stories which gave pains to people through hierarchy relationships.”</i> The movie is a perfect example which makes science and society relatable to each other and presented in a way that easily understandable and with emotions. The movie raised the interest of Matt: <i>“are you saying when science communicate to the public, they are lacking some sort of emotional thing and just talk about facts?”</i> Juanmat made a small change to Matt’s statement. He believe there is a lack of “perspective”. As a scientist, he understand science is complex, but the way science is presented to the public often appear to be so simple and even boring. <i>“We say that it is the DNA is like this, and that it makes the protein.. and forms Ebola, we say it in a way as if it is that simple, but it is not.”</i> While Juanmat implies that scientific facts should not be presented in a brief and “dry” way, Matt pointed out his concern of overdoing it. What troubles Matt is that he often observe media articles that reports a prospect of a scientific finding, instead of reporting the scientific fact. <i>“When we find a molecular that can better recognize cancer, the media says cure for cancer discovered”</i>. Therefore he believe the truth is neither in	Sharing movie of relevant concept Connecting science to society Discussing meaning of movie Social relationship and pain Relation between science and society Science communication Needing emotion Minor correcting Boring presentation Dry expression Opposite concern Middle ground reality

the “dry” fact, nor in the over-decorated media-report manner. But what is at the core of the problem? Juanmat point to the problem of research paper, which often takes a fixed structure of literature, method, experiment, results, etc., which is not how science is actually implemented. <i>“Science at lab is very messy, always in the cloud, we make a mistake, we throw away result...”</i> The core of the problem, is how do we extract that? How do we present it? Should the outside know about it? It is a yes for Juanmat. He believes the way we present our research should include incidence like daily dialogue like “Hey Rebecca, nice discovery!”. Science as a whole should be present, not just the results, in a hollow way. <i>“I imagine to have science paper as movies, so that people can really emphasize on what is really research in science”</i> The “movie” statement soon catches Matt’s eye, and he pointed out that some people is already taking actions: <i>“some nature movie about science process”</i>. But Juanmat doesn’t think this approach is what he meant. He also knows of a journal which accepts a video instead of a paper. But that’s NOT what he meant. He doesn’t want a video to present a paper, he wants a form of publication in which it carries the complexity of science research. <i>“There will be part where there is nothing, there will be part that is contradictory. It is complex and I think movie is a right form for this. It is not like ‘hi, I am Juanmat, I am the researcher and I am going to explain to you about the protein that .. this kind of videos.’”</i>	Referring to real lab experience Comparing reality with presentation Presentation of a complex problem Valuing daily dialogue Presenting the wholeness Movie as new media for science presentation Referring to news reading Opposing the misunderstanding Carrying the wholeness and complexity making example with jokes

Table 9.1 Fieldnotes Taken from B5. “Does Science Communication Need Emotion?”

The discussion started as Lina and Juanmat presented a movie “Mon oncle d’Amérique” as the probe for the discussion. The movie successfully presented a scientific knowledge with a movie, and *“presented in a way that easily understandable and with emotions.”* Matt was a little uncertain about

Lina and Juanmat's intention. Juanmat, sensing the confusion of Matt, made his first **"Evoking"** of his past experience to support his first statement, that *"there is a lack a perspective"* in the science communication.

"We say that it is the DNA is like this, and that it makes the protein.. and forms Ebola, we say it in a way as if it is that simple, but it is not." (Table 9.1)

Juanmat was referring the tone of science communication. But he used a specific past experience to explain what he actually means by saying "lacking a perspective", which is slight different from the statement of "lacking emotion".

Matt also made his version of **"Evoking"**:

Matt pointed out his concern of overdoing it. What troubles Matt is that he often observe media articles that reports a prospect of a scientific finding, instead of reporting the scientific fact. *"When we find a molecular that can better recognize cancer, the media says cure for cancer discovered"*. Therefore he believe the truth is neither in the "dry" fact, nor in the over-decorated media-report manner. (Table 9.1)

This **"Evoking"** helps Matt to better place his point of view on the table. He has clearly demonstrated his concern, an overly decorated science communication may undermine its authenticity. However, Juanmat did not believe they are communicating on the same level of the problem. Therefore he used a continued **"Evoking"**. This time, what he presents is a messy daily routine of his lab life. Juanmat even evokes the daily scenarios like *"hey Rebecca, nice discovery"* to support and communicate his statement.

Juanmat point to the problem of research paper, which often takes a fixed structure of literature, method, experiment, results, etc., which is not how science is actually implemented. *"Science at lab is very messy, always in the cloud, we make a mistake, we throw away result..."* He believes the way we present our research should include incidence like daily dialogue like "Hey Rebecca, nice discovery!". (Table 9.1)

We can see the current "Project" at hand is to build a grounding for "science communication lacking emotion". When the group discuss on the abstract concept and the probing movie, learners engage their personal past experiences, which are constantly being referred to as evidences to support

the their statement. Each “evoking” is built upon the previous context of discussing, so that the current “Project” and its meaning evolves.

9.2 Applying Socio-cultural Meaning

Applying Socio-cultural “Meaning” means the learner apply the associated meaning of the evoked experience to the current Project.

Learners incorporate their socio-historical experience by “Evoking”. They “Evoke” to explain themselves, to comprehend the Project proposition by others, to ground a mutual understanding of certain project and concept, etc. While they do these, they also apply certain socio-cultural meaning to the current project, directly or implicitly. The socio-cultural meaning is associated with the project they evoke, therefore it is not created for the new project, but already established when they first encounter the evoked project in their past learning. The learner applies this established meaning to the current Project as they believes it will fit.

For example, in the previous example (Table 9.1), when Matt evoke his experience of magazine that over decorate science result, he also applies the meaning that science fact needs to be respected with objectivity and accuracy. This meaning he made was not his immediate creation, but already formed when he saw the magazine. Matt evokes the relevant experience and together with the social meaning and applies it to the current project being discussed.

Juanmat follows Matt’s “Evoking” and “Applying” by mentioning the “dry expression” of science publication.

“We say that it is the DNA is like this, and that it makes the protein.. and forms Ebola, we say it in a way as if it is that simple, but it is not.” (Table 9.1)

Juanmat wants to apply the social meaning of approaching science to general public language. This meaning was also not an immediate creation. In other occasion of our observation, he has mentioned many times about the problem of science publication and scientific publication, which inhibit the public from being knowable of science itself.

The “Applying” is ubiquitous. Without applying socio-cultural meaning, the projects evoked are scattered without clear inter connection. The socio-historical project is personal, but the socio-cultural context is common and overlapped. It is only when the learner applies the socio-cultural meaning of

the project, can the other learners comprehend the function of their project and its relation with the current Project.

9.3 Categories of Evoking and Applying

In this section, we will compare the different Evoking and “Applying” cases in our ethnographic data and conclude the different categories of “Evoking” and “Applying”. The categories will help us to better understand the purpose and operations of this basic pattern of “Meaningfulness”.

1. Relevance Evoking and Applying

Every “Evoking” and “Applying” will need to establish a certain degree of relevance, but “Relevance Evoking and Applying” place establishing relevance as its most significant element. “Relevance Evoking and Applying” is the most common form of “Evoking” and “Applying”. Learners use this type of “Evoking” and “Applying” to approach the current Project, to explain their own statement, to comprehend other’s proposal and to ground the mutual understanding of the conversation. Establishing the relevance is the major task for this type of “Evoking” and “Applying”, and learner will understand from their own perspective.

The following is one example of Relevance Evoking and Applying.

The “movie” statement soon catches Matt’s eye, and he pointed out that some people is already taking actions: <i>“some nature movie about science process”</i>. But Juanmat doesn’t think this approach is what he meant. He also knows of a journal which accepts a video instead of a paper. But that’s NOT what he meant. He doesn’t want a video to present a paper, he wants a form of publication in which it carries the complexity of science research. <i>“There will be part where there is nothing, there will be part that is contradictory. It is complex and I think movie is a right form for this. It is not like ‘hi, I am Juanmat, I am the researcher and I am going to explain to you about the protein that .. this kind of videos.”</i>	Referring to news reading Opposing the misunderstanding Carrying the wholeness and complexity making example with jokes

Table 9.2 Fieldnotes taken from B5 “Does Science Communication Need Emotion?”

At the end of the discussion “Does Science Communication Need Emotion?” (Table 9.2),

Matt tries to evoke a past experience that he read:

The “movie” statement soon catches Matt’s eye, and he pointed out that some people is already taking actions: *“some nature movie about science process”*. (Table 9.2)

In evoking this specific experience, Matt tries to comprehend what Juanmat meant by “presenting science with movies”. The “Evoking”, as a part of Matt’s grounding, needs to present a Project at least Matt believe to be relevant to the previous discussion - communicating science with a movie.

But Matt’s relevance does not necessarily present other’s definition of relevance. In what follows, Juanmat again makes a “Relevance Evoking and Applying” to clarify what he means by “science movies”, which is different from the Project Matt just evoked and applied. He specifically evokes a counter Project - a plain descriptive video. Juanmat’s “Relevance Evoking” is on one hand to comprehend what Matt mentions as “some people is already taking actions” and at the same time to make it relevant to his own previous statement

He doesn’t want a video to present a paper, he wants a form of publication in which it carries the complexity of science research. *“There will be part where there is nothing, there will be part that is contradictory. It is complex and I think movie is a right form for this. It is not like ‘hi, I am Juanmat, I am the researcher and I am going to explain to you about the protein that .. this kind of videos.’”* (Table 9.2)

The following “Relevance Evoking and Applying” (Table 9.3) is made by Chris, who was trying to explain his own research field in art and music.

Chris, who hadn’t finished his introduction then felt necessary to complement on his background, as it is not that easy to comprehend than a simple “biology”. He mentioned a coming exhibition in the next week called “living object”, in which artists use installation to explain what they believe as “living object”. He use this exhibition to explain the “ecology” where he works in. The group started to look at the exhibition website when Juanmat immediate found someone (an artist) who he’s heard of but forgot why. Before Chris even had the time to explain, Ke found the work of the artist to be one of his impressive experience. Ke started to	Needing to clarify Similar project in he “ecology” Impressive experience

explain his impressive experience: when the art work was exhibited in China, Ke once saw it was broken by one of the audience, which in turn made it accidentally more respective. One of his friend wrote a review about the accident which she believe adds more meaning to the art work's origin meaning: The "death" of this object (the art work) reflect its "living" status.	Adding meaning to original project

Table 9.3 Fieldnotes taken from B1. Chris's background

Before this "Evoking", he has tried many efforts, such as mention scenography, art and sound combination etc. But as his work is not commonly known to other discipline, many other learners has evoked multiple relevant experience, including an interdisciplinary field, a specific form of art, etc. But Chris still found they are not representative enough. Therefore he himself made a "Relevance Evoking" to present the "ecology".

Chris, who hadn't finished his introduction then felt necessary to complement on his background, as it is not that easy to comprehend than a simple "biology". He mentioned a coming exhibition in the next week called "living object", in which artists use installation to explain what they believe as "living object". He use this exhibition to explain the "ecology" where he works in. (Table 9.3)

"Ecology" was Chris's original wording, which means a set of similar projects to what he does.

2. Familiarity Evoking and Applying

Unlike "Relevance Evoking and Applying", which place establishing relevance as the most prominent feature and purpose, "Familiarity Evoking and Applying" summarizes the type of "Evoking and Applying" that majorly evokes and presents a learner's familiar Project, which he or she feels particularly compelling to evoke and share. "Familiarity Evoking and Applying" is often associated with personal interests and preference.

In the following example (Table 9.4), Juli made a "Familiarity Evoking and Applying" when Chris tried to explain "his background as a scenography with the integral of sound, light, music, and art installation."

The group was in the introduction section where everyone take turns to introduce their background. But it did not follow a strict one-by-one manner. As everyone has different background, the rest of the group needs to	Comprehending others Interrupting

take a short period of time to absorb the information as one was introducing themselves. When the rest tried to comprehend, they interrupted the speaker and started to express their understanding of the issue at hand. The speaker then also responses to the questions. Chris explained his background as a scenography with the integral of sound, light, music, and art installation. This was however not immediately comprehended by the rest of the group. Matt, a biology researcher did not know about “scenography”, and Juli, a science student, tried to relate it to one of a field she knows that seemed similar. The discussion then took a slight detour as Juli started to explain her knowledge of the interdisciplinary field between cognitive science and design. <i>“you know there is a school,... a field that connect cognitive science and design... it is (related to) visual art, sound design”</i> (Juli) Juli is a science student who has a great interest in the cognitive science. She was also quite interested in its application to more practical field, e.g. design. Her notion of the interdisciplinary field started a new round to comprehension among the group. Juanmat mentioned the term “audio-visual” to conclude what he understood for Juli’s description, and Chris recall some artist using brain wave detectors to make art, which seems related to Juli’s description. Juli approves everyone’s attribution and further elaborate that it is about using cognitive science and physics to compose design, art, and music. This small detour was part of Chris’s introduction with Juli’s contribution. In the end, Juli conclude the small detour by saying <i>“I just know this”</i>, which means she just recalled this interdisciplinary that is related to what she believe as relevant to Chris’s background and she thought it was worth to share. It means : “I just know this (which I want to share with you guys)”.	Communicating to match understanding Mutual communicating Inadequate knowledge Approaching from similar experience detouring interdisciplinary as connecting knowledge personal interest initiating sub-discussion mentioning familiar term recalling past experience grounding everyone’s understanding Recalling relevant past knowledge Wanting to share

Table 9.4 Fieldnotes taken from B1. Chris’s background

Chris's background is a bit difficult for outsiders to understand, therefore the other learners start to comprehend it with what they are familiar with. Juli made the following "Familiarity Evoking and Applying" from her own interest in cognitive science and design:

The discussion then took a slight detour as Juli started to explain her knowledge of the interdisciplinary field between cognitive science and design.

"you know there is a school, ... a field that connect cognitive science and design... it is (related to) visual art, sound design"

Juli is a science student who has a great interest in the cognitive science. She was also quite interested in its application to more practical field, e.g. design. Her notion of the interdisciplinary field started a new round to comprehension among the group.(Table 9.4)

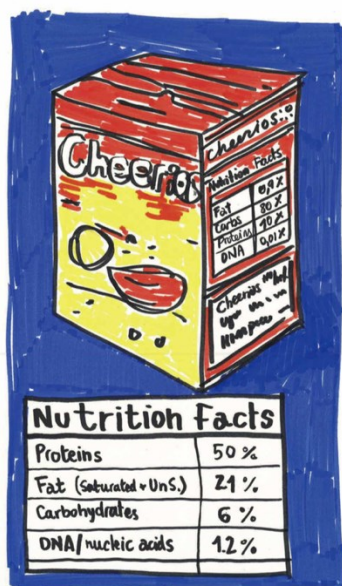
Juli's evoking of the interdisciplinary field even created a small sub-discussion of the field she mentioned. Although it has certain relevance to the topic at hand, it more significantly addresses Juli's own interest, especially in cognitive science. Chris did not mention cognitive science, nor did his field actually has anything to do with cognitive science. But Juli successfully inserted her interest in the current conversation, which turns the "Project" into a hybrid of both Chris's background and Juli's interest of the field. Though part of the purpose was to establish a relevance, but the evoking eventually triggers a detour of discussion. At the end of the this sharing, Juli concluded her actual contribution:

This small detour was part of Chris's introduction with Juli's contribution. In the end, Juli conclude the small detour by saying *"I just know this"*, which means she just recalled this interdisciplinary that is related to what she believe as relevant to Chris's background and she thought it was worth to share. It means : "I just know this (which I want to share with you guys)". (Table 9.4)

Juli's example demonstrates that the learner who conduct a "Familiarity Evoking" are likely to associate with a "want to share" intention.

Sometimes, the Familiarity Evoking and Applying might bring in a complete different perspective, as illustrated in the following example. (Table 9.5)

Juanmat was the first to present his story. He wanted to think of something new, something outside bio-engineering with which he is so familiar. *“I want to get rid of all the preconception I have.”* He focus on what he calls the *“social impact of scientific vocabulary”*, and particularly the concept of DNA. He imagined a daily scenario of a future kitchen where a family is having their breakfast. While everything else seems normal, there is one thing strange: nutritional fact table on the “Cheerios” (Cereal food brand) marks the DNA content. Juanmat drew the “Cheerios” out, and everyone laughed when they noticed the DNA content on the label: how funny! Normally, DNA is not put on the nutritional fact table, as it does not count as nutrition. But Juanmat rationalized this as a mark of the “naturalness” of the food: the more DNA it has, the more natural the food is, since it has more organic compound and less chemical ones.



Name: JUANMA GARCÍA

Topic/reference/technology of interest
Social impact of scientific vocabulary / pop science

Who(Person/Animal/Bacteria)/When (Immediate or future?)/Where does this scenario take place?
in everyday's life, people, families,

Questions to consider:
 - What happens in your scenario?
 - What is your attitude towards synbio?
 - If you are stuck - think of the details. What will the technology look like a physical form? How will it interact with the person interacting with the technology?

In this scenario, people learn and take part of the scientific vocabulary, using metaphors in their daily life. DNA is advertised as food and a higher expectations is taken.
 1) Cheerios packages with DNA content.
 2) Science vocab that evolve over time... (oh, that's so 80's.) Science meta-culture.
 3) How maybe not modified or natural bacteria or organisms get to change people's life.

> punine ingestion <

THINK DESIGN ART
 IMPROVING YOUR DESIGN
 SKILLS

CO-LAB
 コ・ラボ

So DNA becomes as good as a kind of nutrition like protein! But soon this speculation was challenged by Pratek, a participant with biology background. Pratek pointed out that DNA is phosphoric acid, which *“isn't cool”* for people's health. This argument soon evoked a round of discussion on the chemical component of DNA and their nutritional value. The “phosphoric acid” argument was debunked by Juanmat by saying that the “phosphoric acid” is not free in the DNA, but instead confined in the chain as part of a larger

Outside of comfort zone
 Trying new things
 Getting rid of preconception
 Society and science

Abnormal reality

Feeling strange and funny

Rationalizing abnormality
 Science concept meaning making

Entering question from a different perspective
 Evoking discussion of a different perspective

Discussing on science

Comparing a daily example

chemical: <i>"It is like saying coca cola has carbohydrates because it has CO2</i> (which is not correct because CO2 is just a part of the carbohydrates and not free to move away from the main part)." But Caline, a participant with both biology and design background, argued that another component of DNA, the "purine" might add kidney's burden as she once learned in a medical course. Her arguments seems more evidential to the other participants, but Juanmat argues that the burden also exists when one has too much protein. The biological discussion continues as Matt wants to calculate the exact number of the DNA content. The biological discussion was not expected in Juanmat's original idea. His intention was about the <i>"social impact of scientific vocabulary"</i>. But When he made the claim that the DNA is seen as a kind of nutrition, as a sign of healthier food, people started the above discussion.	Referring to past knowledge Unexpected different perspective Raising discussion

Table 9.5 Fieldnotes taken from B6. Labelling the DNA content

In the above example, Juanmat, as required by the "narrative workshop", first propose a abnormal narrative: "nutritional fact table on the "Cheerios" (Cereal food brand) marks the DNA content." Juanmat wants to justify this speculation by stating DNA is a mark of nutrition as "the more DNA it has, the more natural the food is, since it has more organic compound and less chemical ones." But this statement was immediately challenged by Pratek who made a "Familiarity Evoking" of biological and chemical knowledge of DNA :

Pratek pointed out that DNA is phosphoric acid, which *"isn't cool"* for people's health. This argument soon evoked a round of discussion on the chemical component of DNA and their nutritional value. The "phosphoric acid" argument was debunked by Juanmat by saying that the "phosphoric acid" is not free in the DNA, but instead confined in the chain as part of a larger chemical: *"It is like saying coca cola has carbohydrates because it has CO2....* But Caline, a participant with both biology and design background, argued that another component of DNA, the "purine" might add kidney's burden as she once learned in a medical course.(Table 9.5)

Pratek has a biology science background. His proposal of nutritional value is not entirely correct as we can see in the following debate, but he successfully guided the discussion into a biology and chemistry one, diverting from what Juanmat's original Project (the relevance is low). Pratek made such "evoking"

because he believed it is important to check the biological knowledge. It is a “Familiarity Evoking” based on Pratek’s disciplinary training.

Under the category of “Familiarity Evoking and Applying”, there is a special type associated with what we code as “impressive Project”. It denotes a Project that is so impressive to the learner, so that they feel compelling to evoke and share.

In the previous example of Chris's background (table 9.3), Ke made a "Familiarity Evoking - Impressive Project".

Before Chris even had the time to explain, Ke found the work of the artist to be one of his impressive experience. Ke started to explain his impressive experience: when the art work was exhibited in China, Ke once saw it was broken by one of the audience, which in turn made it accidentally more respective. One of his friend wrote a review about the accident which she believe adds more meaning to the art work's origin meaning: The “death” of this object (the art work) reflect its “living” status. (Table 9.3)

Ke's mention of this project does not really contribute to Chris's background. He made the "Evoking" because this event was so impressive. When Ke saw the picture of the Project, he immediately shared with the others.

3. Boundary Evoking and Applying

“Boundary Evoking and Applying” lies in between “Relevance Evoking and Applying” and “Familiarity Evoking and Applying”. It normally evokes a Project that both connects to one’s own interest / point to view, and at the same time establishes a connection to the group. “Boundary Evoking and Applying” is particularly associated with Projects that are easy understandable to different group of learners.

The following example (Table 9.6) marks a “Boundary Evoking and Applying” of a daily scenario.

The biological discussion was not expected in Juanmat's original idea. His intention was about the "<i>social impact of scientific vocabulary</i>". But When he made the claim that the DNA is seen as a kind of nutrition, as a sign of healthier food, people started the above discussion.	Raising discussion
When the biological discussion ends, Juanmat continues his story. This future kitchen has a green window full of algae and	Daily expression with

another window with red bacteria that is good for health. The mother was talking about engineering and fitness, while the son told mom that these topics were so “80s” and not fashionable any more, science vocabulary is the current new faction ! When Juanmat finished his future scenarios, he also speculated how his speculation could be realized at the moment by implementing “science activism” actions. He proposed that the group can maybe go to the street and put on stickers (like “containing DNA”) to the food. He got this inspiration from the artist group who made fake corporate advertisement that ironically reflects their indifferent attitude towards the environment. The artist and activists puts those fake advertisement in the light box of bus station during the COP21 conference in Paris as if there were real advertisement by the companies(This happens in Paris around the time the workshops took place, so everyone has real life experience with it). (<u>Johnson & Johnson, 1989</u>) “Ah, that’s nice!” The group hailed to this proposition, and started to discuss the fake advertisement activism which many of them knew or even witnessed. Inspired by this, Matt proposed that designers can design the stickers to mimic real stickers on food, just as the artist mimic the advertisement. Ke proposed to design not only “containing DNA” sticker, but also “no DNA at all” stickers, which immediately echoed by Pratek: “Yes, like DNA free” “Yeah, yeah”. Creating a science activism ignites everyone’s imagination. We saw ideas after ideas coming up. Pratek propose it is possible to actually extract the DNA with alcohol or soap, (he knows it as he has done it in his biology experiments) and sell it as a kind of food addition. This idea soon inspired more ideas to make DNA concept shop, DNA products, and DNA level certificate etc. The rationale of this is that all this activism can push people to think more about the science concept, so that people can really understand the science behind instead of just following false understanding, one of which Juanmat knew, is about a report saying carrot has a lot of DNA and eat carrot will make people yellow as the DNA starts to translate inside human. The yellow effect is true, but it is not how DNA works.	Science vocabulary Future to current Performing street art Inspired from on-going street art Reference of daily acquittance Receiving accomplishment Resembling past reference An opposite proposition Igniting passion Outburst of ideas Inspired from past experience

	Extending narrative Presenting rationale

Table 9.6 Fieldnotes taken from B6. Labelling the DNA content

After Juanmat's introduction of the speculative story of DNA as nutrition(see table 9.5 for more detail), he evoked a street art to connect his story to reality:

When Juanmat finished his future scenarios, he also speculated how his speculation could be realized at the moment by implementing "science activism" actions. He proposed that the group can maybe go to the street and put on stickers (like "containing DNA") to the food. He got this inspiration from the artist group who made fake corporate advertisement that ironically reflects their indifferent attitude towards the environment. The artist and activists puts those fake advertisement in the light box of bus station during the COP21 conference in Paris as if there were real advertisement by the companies(This happens in Paris around the time the workshops took place, so everyone has real life experience with it). (table 9.6)

"Boundary Evoking and Applying" does not only concerns one self, it serves as a media between the speaker and the others. In this example, Juanmat just finished the speculative story, and he wanted the story to be exhibited in reality. His solution is a kind of "science activism", and he use the example of "COP21 fake advertisement" as a bridging Project for his idea. The COP21 perfectly represents Juanmat's idea of science activism, but it is also a public event, widely reported during the workshop. Therefore most of the participants know this event and soon establishes their understanding. Juanmat could have made an evoking of old less known art activism, but then it is more likely to be a Relevance Evoking and Applying. When he manage to use of a hot public event as a bridge to connect the other group, he made a successful Boundary Evoking and Applying.

The following example(Table 9.7) presents another example of "Boundary Evoking and Applying" when Lina tries to present the "narrative workshop".

Lina is presenting a few examples before the narrative workshop. She straights out the purpose for the workshop,	Making examples Expressing purpose

which is to generate conversations and allow design perspective in the scientific “fabrication of facts” (refer to D1 fieldnote 3). She has to make the science people understand the importance of this purpose before she can deliver the workshop. Therefore her presentation is essential. She chose to directly showcase the design projects to present the “design perspective”. These examples are not random, you can see she purposely chose design projects related to life science so that the biologists feel more attached to their life. The first project is about the utilization of a bio-degradable material – mycelium: low-technique but quite strong in terms of rigidity and fire-proof. The exploration of such materials, not necessarily high-tech but useful is one of the promising direction for designers. Another similar project features the use of natto – a Japanese traditional ferment food, as natural material to detect humidity. The exploration of material is one thread of the design science collaboration story. Then Lina introduces another thread which intends to bring design narrative to science. For example, one of the design project speculates a technology to help homosexual parents to have children with both their genes, which is inspired by a true science. The designer not only speculates the technology, she also create the life story for a couple, what is the families’ life like. She creates a film with computer graphics, which moves Lina a lot. It is touching because Lina can actually see the technology being used and feel the reality of the science. Another designer makes a genetic modified flower which reverse a GM flower to its original status. It creates a paradox of whether it is GM, as at one hand it is made with GM technology, but at the other hand it de-modify its artificial features to return to its origins. The paradox further provoke the question of what GM is and how should we see and deal with it. In the third project, the designers collect gums on the street and visualize their owners based on the DNA on the gums. The visualization is on one hand a technology, but on the other a question on the security and the rights of such information we randomly give away everywhere. For Lina, These are the stories illustrate her purpose in this narrative workshop. These speculative design, or design fictions, help to relate the technology to people, to life and to	Design perspective in fabricating facts Presenting to make people understood Showcasing projects Relating to the other discipline Usable bio-material Ferment food Design narrative into science Speculating sci-fi with design perspective Designers making movies Audience Feeling touched Feeling the reality of science Creating controversy GM discussion Raise awareness of bio-info Using example projects Relating technology to life

the socio-cultural context of where it is being or will be used. It helps to imagine a future where technology is being considered with a design perspective. For Lina, they either asks a question, or frame the technology to a context so that it is easier for people to comprehend with their daily life experience. And in this workshop, she wants everyone to make these kinds of narratives so that different perspectives can clash and hopefully we can find a way to learn from each other and integrate.	Future with design perspective Framing technology to a context Making narrative to engage different perspective

Table 9.7 Fieldnotes taken from.B4. Lina’s design examples

When facing a group of biologists, Lina wants to present the narrative power of design narrative. She chose “Projects” that both demonstrates the design perceptive but at the same time deeply concerned with biologists’ daily work:

These examples are not random, you can see she purposely chose design projects related to life science so that the biologists feel more attached to their life. ... For example, one of the design project speculates a technology to help homosexual parents to have children with both their genes, which is inspired by a true science. The designer not only speculates the technology, she also create the life story for a couple, what is the families’ life like..... Another designer makes a genetic modified flower which reverse a GM flower to its original status. It creates a paradox of whether it is GM, as at one hand it is made with GM technology, but at the other hand it de-modify its artificial features to return to its origins.... In the third project, the designers collect gums on the street and visualize their owners based on the DNA on the gums. The visualization is on one hand a technology, but on the other a question on the security and the rights of such information we randomly give away everywhere.(Table 9.7)

To conclude:

1. “Relevance Evoking and applying” is the most common form, which puts relevance in the center. Learner use this evoking to ground their understanding of the joint Project and the other learners.
2. “Familiarity Evoking and applying” centers the speakers’ own interest and perspective. Although the evoking must have some relevance to the current Project and others of the group, it is not as important as the speakers’ own familiarity of the project. Sometimes, it is associated with a change of topic, or a very impressive project.

3. “Boundary Evoking and applying” is a combination of both considering making relevance, explaining oneself and connecting others. The purpose is hybrid, and very often associated with project that is very understandable to other learners.

It is important to note that the three categories are not mutually exclusive. Most works in a hybrid way. When the learner feels compelling to share, he or she might make a “familiarity evoking and applying”, but soon find out he might need further relevance evoking and applying or boundary evoking and applying to supplement. The reality always exists in a mix of different categories.

Chapter 10. “Prioritizing”: the Underlying Pattern

In this chapter, we will study the underlying pattern of “Evoking” and “Applying”. What “Project” do learners “Evoke” and what “Meaning” do they “Apply”? What rules do they follow when they choose what to “Evoke” and “Apply”? Is it a formula-like rule so that every time it will be same “Project and “Meaning” given the learner’s inherent knowledge and experience? Is “Evoking” and “Applying” a one-to-one mapping, so that given a current “Project”, a learner will come up with only one pair of past “Project” and associated “Meaning”? In this chapter, we will further study the underlying mechanism to address the question above mentioned.

We compare the different situations with our ethnographic data and generated a focused code for the underlying mechanism: “**Prioritizing**”, which summarizes the following phenomenon:

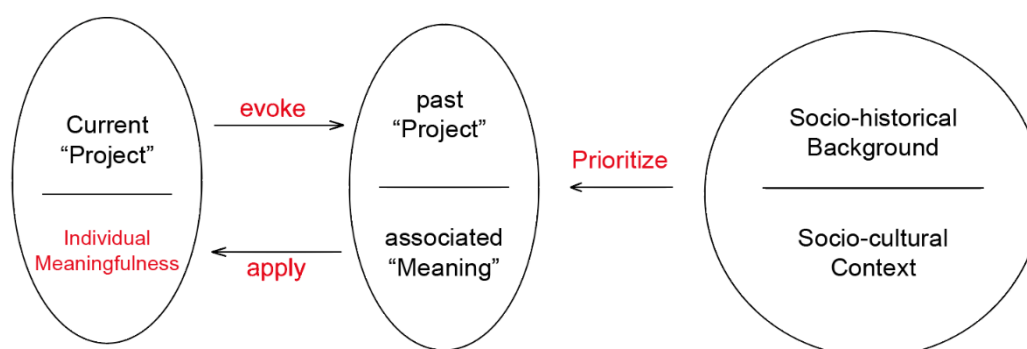


Fig. 10.1. Illustration of Evoke, Apply, and Prioritize

1. The “Evoking” and “Applying” has a manifold potential. Whatever the learner evokes and applies, it is essentially rooted in his or her broader socio-historical background and socio-cultural context, which consists of multiple potential P and M that could be relevant.
2. P/M emerges as only the most prioritized P and M. The prioritized Project and Meaning is a representative of the project and meaning that is most significant and suitable for the current project.
3. We summarized two categories of “Prioritizing”: the “Inherent Prioritizing” and the “Situating Prioritizing”. The “Inherent Prioritizing” means the selection is subject to the inherent preference that the learner built in his or her socio-historical learning. The “Situating Prioritizing”, on the contrary, forms during the workshop. It is subjected to incidental factors of the workshop: the discussion, the reaction of others, incidental interruptions, the self and environmental factors, etc.

Therefore, the individual Meaningfulness constructed through a dynamic process of “Prioritizing”, “Evoking” and “Applying”. The “Prioritizing” compares different Project and Meaning that might have relevance and then select those one find most suitable. Finally, the “prioritizing” does not follow an formula-like rule, it is both “inherent” and “situated”.

10.1 The Multiple Potential P/M (Project/Meaning)

The Emerged Multiple P/M

In most cases of our ethnographic data, the learner will evoke one “Project” and apply the “Meaning” to it. This is the simple and singular pattern of “Evoking” and “Applying”. But the singular form is not the only form of “Evoking” and “Applying”. In some other cases, there are multiple “Projects” evoked and “Meaning” applied.

In the following example(table 10.1), Lina use two similar projects, to explain the meaning of designer’s perspective of “fabricating the fact”

Lina’s project got inspired by a group of scientists who are working on grow human organs on pigs for the use of transplant. More specifically, they are finding ways to use CRISPR(a gene editing tool) to get rid of the virus so that pig organs are safe for transplanting to humans. But as a designer, Lina’s eye on the facts turns to other perspectives: e.g. she asks who is going to manage the transplant and where will it be implemented. When she found out the government is in charge of managing transplanting, she realized the conflicts between the private company who funded the research and the government might need a solution. She also wants to know how in reality it will be implemented in the society: People might view pig very differently; the conflict between society use and nature living, the hospital scenario where the patient will need to choose from wait for natural human organ transplant or pig organ transplant; etc. She is concerned with these issues and believe her perspective can be involved in the science research, or, as she quotes Bruno Latour, in the “fabrication of facts.”	Using past example to clarify the “fabricating facts” Designer looking at A real science project A alternative perspective Social reality Sensing conflict Implement science in reality is an issue Social controversies

The pig example raised Juanmat's interest, and he reminded that in some areas, pigs are somewhat unsacred, and in some other areas, pigs are religious. Growing human organs on pig might create political and religious issues. Matt starts to understand this. He thought about the insulin grown in pig that is used in diabetes, which is not a big problem to scientists. For him, the science world seems to accept those issues quite fast. But he also understand what Lina meant by the different perspective of the issue. <i>"It makes sense to ask those questions"</i> Another example Lina made is a synthetic vanilla made by a group of scientist. They claim it to be closer to natural hence healthier, as the vanilla now we use are basically chemicals. But then Haagen-Dazs says they will not use it as it is genetically modified. And the consumers also does not want to buy it. The conflicts is between the scientists' fact, which is a healthier and probably cheaper vanilla, and the another fact, which is GM not acceptable to Haagen-Dazs or the consumer. Lina says she does not think the research is a waste, but she suggest a collective perspective and a better communication once the science research is actually implemented in society.	Involving different perspective Reminding social norms Raising political aspect Starting to understand Bringing in relevant but slight different example Admitting designers' perspective has meaning Giving another example Natural vs GM

Table 10.1 Fieldnotes taken from B3. What's interdisciplinarity

The first "Project" was Lina's own project pig organ transplant. Scientists are working on the biological solution of safe organ pig transplant, while Lina's project is to investigate who will actually implement the technology, where and how it be will done. She believe her perspective should be part of "fabricating the fact", which now is often the job of the scientists. While the two scientists Matt and Juanmat are starting to understand her point, Lina starts to evoke another similar project. A GM vanilla flavor produced by the scientists, claiming healthier and more natural than chemical vanilla, got refused by Haagen-Dazs because GM product is not easy to be accepted in the market. This "Project" was evoked by Lina to reinforce her meaning mentioned above. Both the pig organ project and the GM vanilla project represent her perspective that scientists need to incorporate more perspective when "conceiving" and "fabricating" the "facts". The only one "Project" was maybe enough in explaining her "Meaning", but two similar "Project" might be more complete and accurate. From the later progress of the workshop, we know that Lina's explanation was well accepted by Matt who had the confusion in the beginning.

Lina conducted a multiple evoking again in her presentation where she used three new design examples to make her point of a similar meaning. Unlike the above mentioned science “Projects”, these “Projects” are all design projects. They are the reflections by the designers to science projects. Lina evoke these projects to apply a similar meaning from the other side of the coin.

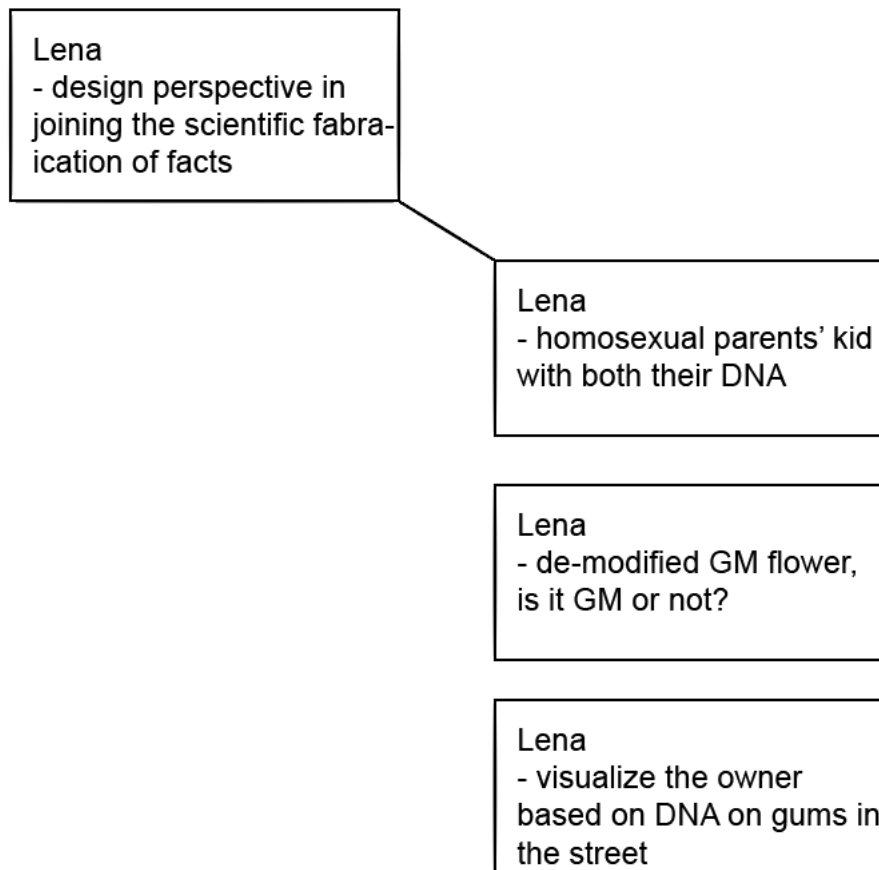


Fig 10.2 Lina's design examples

Besides similar Projects for the same “Meaning”. There are also multiple similar meaning evoked and applied in the collaborative learning.

In the second CoLAB example, Denqing presents a cluster of related meaning that he generate from his past project experience, which are “designing rules”, “interaction”, “connectivity”, “non-linear narration” and “transformation”. (table 10.2)

We add one more meaning to his summary: “Rule reinventing”. For him, the most meaningful interaction design seems to be a design that reinventing the rules:

Therefore, the basic feature units are
“interaction ” “connectivity” “nonlinear narration” “transformation” that

describe the entry and perspective that a designer might take as entering tools. And the “rule designing” is a higher level feature which is the emphasis on all the above features. The rule to interact, to establish rule.... Denqing seems to present a stance that Interaction designer should know that their ultimate focus is the rules of these different entry point. And the final implicit feature is that the designing should to some degree to be creative and challenging the status quo, to have the power to say that I am making a new and radical change to the existing rules, to reinvent the rules (taken from fieldnotes C1.)

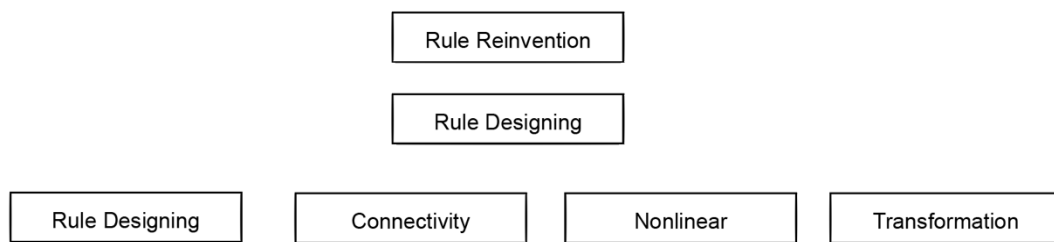


Fig10.3 Denqing's cluster of "Meaning"

The different meaning he tries to apply to the workshop are different, but still, it is related. Denqing uses this cluster of "Meaning" to approach what he believes as meaningful. He hopes the learners can comprehend these different but related meanings. The multiple meaning as a cluster does have a coherent and strong impression to the student, as the students often recall that the design of Denqing is "untraditional".

Also, there are situations, one learner might evoke and apply significantly different "Project" and "Meaning" towards a single current Project.

In the following example, Pratek and Juanmat both have evoked "Project" and "Meaning" in two separate directions. The first line of the "Project" and "Meaning" is about biological facts of DNA, while the other is more concerned with the science communication in a society. When Juanmat explained his narrative that DNA labels can be seen as a sign of natural food, Pratek did not immediately evoke his experience of science communication; instead, he evokes his experience in biological learning and started a thread of discussion of whether more DNA is better. But it does not mean he did not have any experience about science communication that can be evoked and applied. In fact, in just a few minutes later, when the discussion shifted to science activism, Pratek was approving the idea and gave his contribution to "extract DNA and sell" as a part of the positive labelling of DNA.

This double thread also appeared to Juanmat who started the "Project". He did not expect the biological fact debate to happen, but while they started the separated thread, he also joined the discussion and made serious analysis:

The “phosphoric acid” argument was debunked by Juanmat by saying that the “phosphoric acid” is not free in the DNA, but instead confined in the chain as part of a larger chemical: *“It is like saying coca cola has carbohydrates because it has CO2 (which is not correct because CO2 is just a part of the carbohydrates and not free to move away from the main part). (taken from fieldnotes B6.)*

Juanmat is a biological background student. So his disciplinary background and knowledge allows him to quick react to Pratek’s question and to debunk. But he is also interested in the science communication and the society’s perception of science, therefore he started this project and guided the group to return to this line of “Meaning” after the biological debate. Both “Meaning” was applied by Juanmat as well as Pratek.

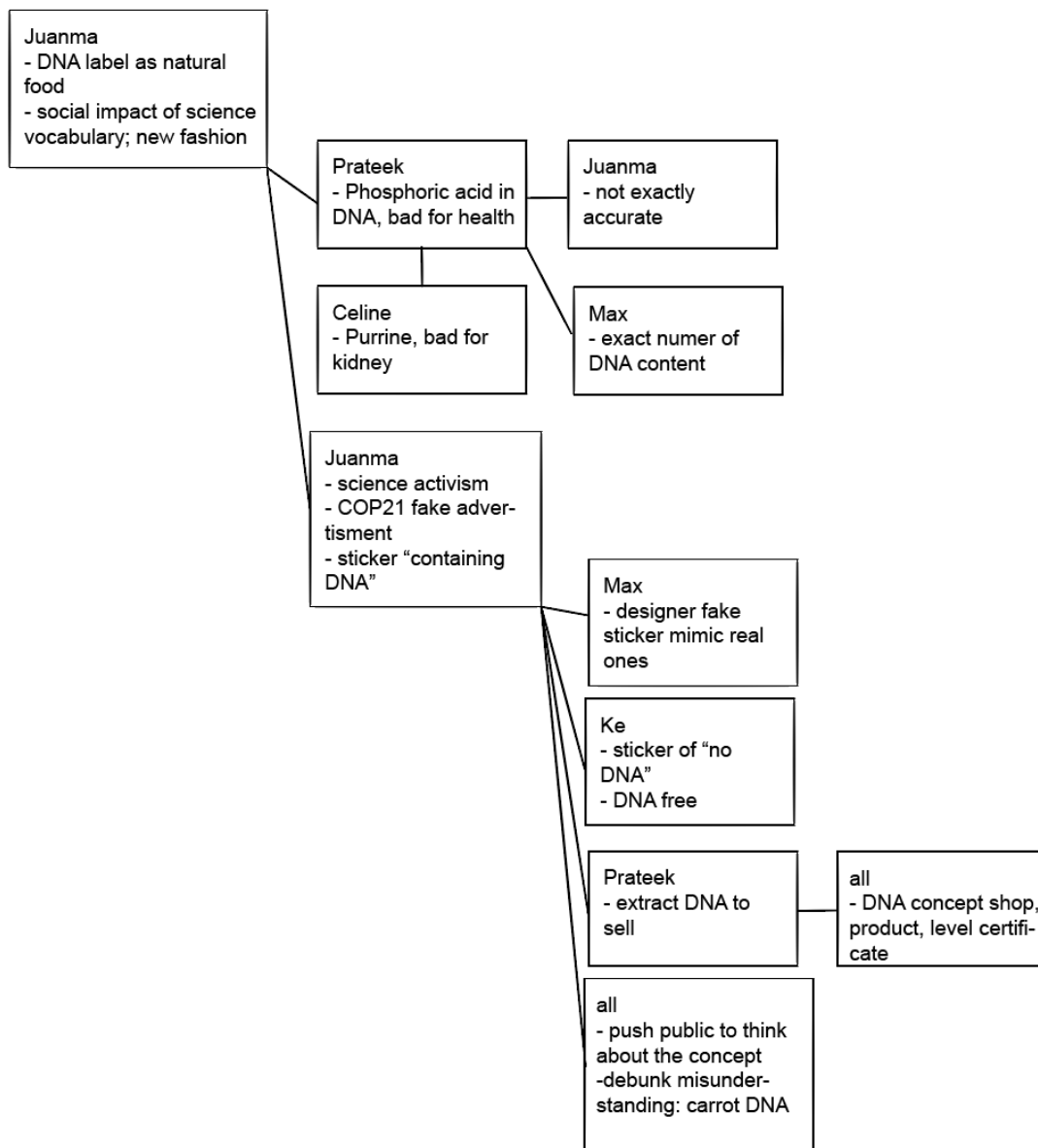


Fig 10.4 example of the two thread of “Project” and “Meaning” from B6

The different situations of multiple “Evoking” and “Applying” proves that this basic pattern is not a singular process. The current project has potentially multiple ways to connect to the learners’ broader socio-historical ground and the socio-cultural context, which includes:

1. Multiple similar Projects
2. Multiple similar Meaning
3. Multiple heterogenous Project and Meaning

There are more than one options, and the multiple possibilities, whether similar or distant to each other, are attributed to the learner’s own socio-historical learning and the socio-cultural context where their understanding builds on. They are not confined to only disciplinary knowledge, as we can see in the examples, but exist because the learner has experience the “Projects” and established the meaning in life.

The Oppressed P/M

In the previous cases, multiple “Project” and “Meaning” emerges from the collaborative learning, which proves the “Evoking” and “Applying” has a manifold potential. In this section, we will focus on another significant code “Oppressed P/M”, which we generate from the initial codes. “Oppressed P/M” cast lights to the situation where the learner’s “evoking” and “applying” was neglected or oppressed due to multiple reasons: being cut off, interrupted, redirected, or forgotten. The following example showcases one of the Oppressed P/M situation.

There is one small incidence took place in this stage which is noticeable: when Xiaoding (the designer) ask if the sensor can be something in the city, e.g. oil container. The answer was quickly given by one of the biology student, that sensor is a receptor, a receptor reacting to a specific trigger, with all the scientific explanation followed. He was not considering why Xiaoding asked the question in the first place. But if we look back the question, why does Xiaoding ask about something in the city, why she give specific example like an oil container. As a designer, instinct tells me that the girl has something to say about the example, which is not very much about science, but about the functionality of the object itself. Might be that oil container has some special meaning that is worth exploring.	asking alternative function quick answering scientific meaning reason for original question alternative meaning

The idea was not even developed, but just as a “baby proposition”. this “baby proposition” just take the form of one very easily neglectable sentence, and its full meaning that might exist in the designer’ mind but soon disappearing in the driving meaningfulness of the discussion happening at the moment. We will never know what the implication of the girl, which might has the potential to redirect the project, to nurture new creativity. It is not a pity, these small incidence happens all the time, and it is impossible to get every implication spoken out and developed, if that is to happen, there is not time, and the project will go nowhere. But this small incidence is unnoticeable, that some ideas are easily overwhelmed by the driving meaningfulness.	small project proposition neglected project oppressed meaning driving meaningfulness potential new direction regular neglecting under developed project proposition

Table10.2 Fieldnotes taken from C5. Science and romantic

In the example above, Xiaoding was the only designer in the team. She actively tried to participated in the group discussion, but often felt she could not be effectively involved. In a later interview, she explain what she believes the reason lies:

“I really wanted to participate, to contribute my knowledge and skill, but they are all very professional in the technology ... I felt only 20% of my participation was somewhat useful, and the reason is that I think I do not have the knowledge to quickly respond. I need time to reflect on what they say.” (interview Xiaoding)

Xiaoding’s self-explanation aligns with the fieldnote above. Her proposal of using a city object, e.g. an oil container, as a carrier of bio-sensor, was quickly neglected. And this neglectation does not happen on the “Project” level, as one of the biology student did give his answer about the technical detail of a bio-sensor. But he neglected the fact that Xiaoding was not proposing the city object as she trying to find a technical solution, but trying to propose a scenario where human and object interact. Xiaoding actually agrees with the technical aspect of the project, but she also constantly has the intention to propose the “scenario” consideration. This intention appeared again in a later discussion.

When discussing on the project, the designer Xiaoding kept on mentioning scenarios. She was more comfortable to put the object into a scenario or a story then discussion on the object of its own. For example, when the other members of the group was focusing on the specific object that can change color, they mentioned the air itself can change color. But Runda oppose to

that idea saying that a room of red color air would make it scary to breathe. This scenario soon caught Xiaoding's attention. She immediately added: "So we are looking at a scenario where there will be some human interaction right?" While the others were discussing on the object, Xiaoding was thinking about the scenario, whether there will be people and whether they will interact in it. (fieldnotes taken from C6. the science fiction)

The focus of scenario and human interaction came from Xiaoding's disciplinary training. In her design lesson, the projects she made emphasized a lot on the interaction scenario, e.g. how does a person interact inside a blood donation van. She tries to "evoke" and "apply", but her "Project" and "Meaning" was oppressed as the main meaningfulness during that time was the technical part of the object, her proposal from an alternative was not comprehended nor developed. Similar incidence happened multiple times in this workshop, and that's why Xiaoding felt only 20% of her work was effective.

In the case of Oppressed P/M, there emerges a borderline of "Project" of "Meaning". The multiple P/M is not salient as in the previous example of DNA labelling where both "Meaning" appears on the table, but it also leaves a trace of the Oppressed P/M which could have the potential to be developed, but disappears in a flash.

The Multiple Potential

To conclude, the emerged multiple P/M evidently reveals that the P/M actually evoked is not the only P/M that has the potential to be evoked. They are more "Project" and "Meaning" to be evoked and applied. The oppressed P/M presented a borderline Project and Meaning between the emerge and the immersive one. These Oppressed Project and Meaning also has the potential to be evoke but got neglected or oppressed by other "Project" and "Meaning". These are all evidence to summarize that the basic pattern of "Evoking" and "Applying" have a multiple potential. What emerges is only a fraction of what actually has the potential to be established. The potential P/M lurk in in the socio-historical background and socio-cultural context, as shown in the following illustration.

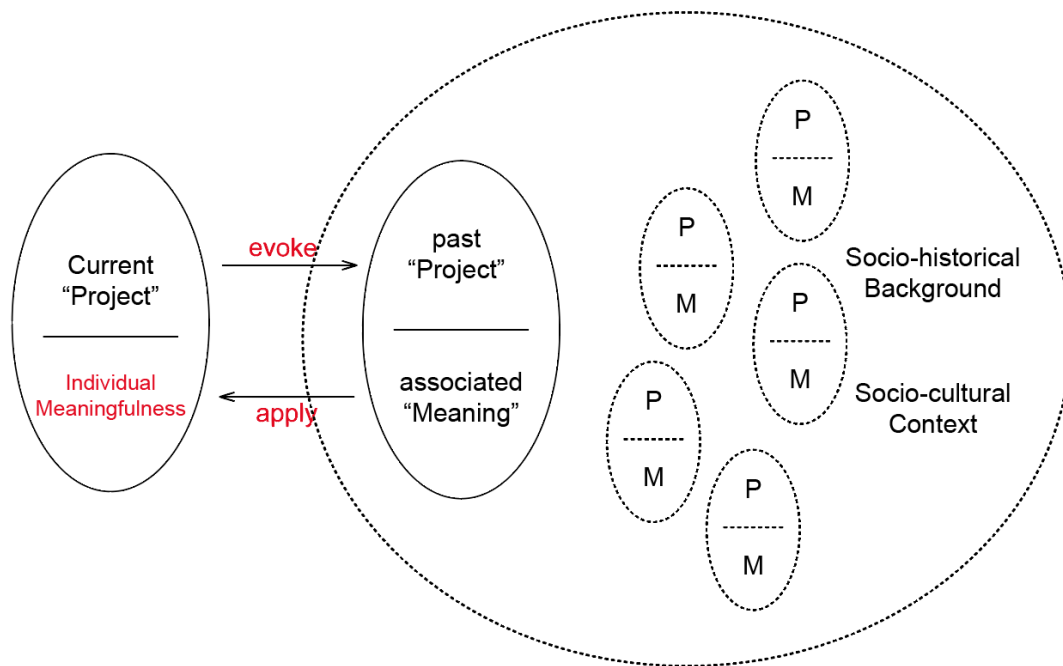


Fig 10.5 illustration of multiple potential.

Though the potential is broad, the learner cannot evoke and apply every P/M potentially connected. From the emerged multiple P/M examples we know, there are certain conditions in which P/M was chosen to emerge, while in the oppressed P/M example, we can see the emerging is limited and can be oppressed due to the intensive pace of collaborative work, limit of time, misunderstanding, or neglect etc.

As the emerging opportunity is limited, what leads to the successfully P/M to be selected to evoke and apply? What rules determine this selection? We will further analyze the above questions in the next section.

10.2 “Prioritizing” : Selecting P/M from the multiple potential

What Project and Meaning from the potential pool of P/M is actually selected to evoke and apply, and why? What P/M will be oppressed or neglected and why? In answering these question, we further study the ethnographic data of the co-lab workshops and conclude a focused code “Prioritizing” that interprets the selection of P/M from the socio-historical background and socio-cultural context.

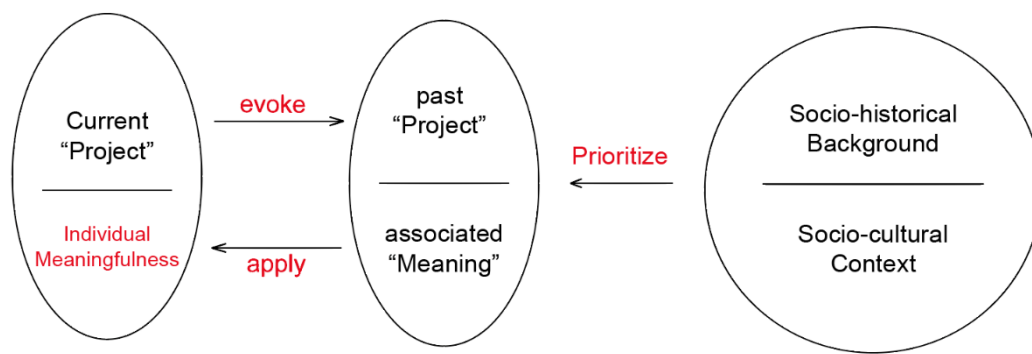


Fig. 10.6 Prioritizing from the socio-historical background and socio-cultural context

Two key categories of “Prioritizing” are generated: the Inherent Prioritizing and the Situated Prioritizing.

The “Inherent Prioritizing” means the selection is subject to the inherent preference that the learner built in his or her socio-historical learning. The “Inherent Prioritizing” can form long before the workshop takes place, and is often associated with personal interests, intrinsic motivation and attitude. The learner will select the P/M that fits his or her inherent preference and oppress the ones irrelevant to his or her constant value or attitude.

The “Situated Prioritizing”, on the contrary, forms during the workshop. It is subjected to incidental factors of the workshop: the discussion, the reaction of others, incidental interruptions, the self and environmental factors, etc. In “Situated Prioritizing”, learners will be influenced by the situation, and prioritize P/M that normally does not fits the learner’s inherent preference, value or attitude. This type of “Prioritizing” marks the development of the learners’ inherent prioritizing, which will possibly impact the learner’s future learning.

Inherent Prioritizing

We generate the categories “Inherent Prioritizing” from the ethnographic study of key learners in the Co-lab workshops. In comparing the ethnographic observation of different workshops as well as daily conversation, we can find consistencies of personal preference of Project and Meaning that have been constantly evoke and apply, which we code as “Inherent Prioritizing”. The

following ethnographies give example of inherent prioritizing as we study the individual motivation and their prioritizing in the workshop.

Juanmat is one of the founder of Co-lab workshop. Before he started the workshop series, he received his master degree of interdisciplinary study of biology. It is a degree that encourages interdisciplinary collaboration. Therefore, during his master, Juanmat joined the iGEM competition in which he worked with designers to explore the societal aspect of their project. In his spare time, he also co-founded the student association Open Science School to promote open education for all. Most co-organizers of Co-lab workshop join to work as a member of Open Science School.

Juanmat has a broad personal interests besides biology study, e.g. art, design and politics. Juanmat enjoys to practice art and design. In some of the workshop, he wanted to take the designers' job of making the poster. He learns as he works with people of different background. During the co-lab workshops, he got the habit of using tools that designer often use, such as post-it and mind map, which he claimed to learn from the designers.

His open attitude also extends to scientific education and research. The Open Science School was first established to teach high school student about synthetic biology with open sources hardware and online course. The hands-on practice that uses synthetic biology In open science school. Open education is a big part of his academic life although it is not the focus on his lab when he continues to do his Ph.D after his master. He joined first three version of the global conference on open hardware conference GOSH.

These practices have been often evoked in the workshop. For example, the following fieldnotes was taken from one of the workshop:

Juanmat complement on this point from a similar but slightly different perspective. He mentioned using synthetic biology lessons to high schoolers as an introductory lesson to science in general. He had one experience with that in the previous summer, when he aggregate dozens of high schoolers in a student lab and teach them about synthetic biology. He also mention a NGO "bio-builder", from whom he got the inspiration. To Juanmat, the synthetic biology brings in the openness from its simplicity.

"It is so simple, like a black box, you have the genes and then what see what you do and get the result, sometimes dangerous, yes, but very simple."

This simplicity, to Juanmat is a good feature that allows high schoolers and outsiders to open a door to the science world. He believe it is not only the laws, facts, results – but the meta knowledge that makes science: how scientist work, how to write science, how to talk like a scientist, etc. (fieldnotes from B2. Matt’s motivation)

The high school course Juanmat gave is a priority Project that he had worked on in the summer the co-lab. This course was very often brought up by Juanmat as one of his preferred examples. He and other members of the student association kept developing an open hardware kit after the course and even started their own company in Shenzhen China for making the hardware three years after the course.

The prioritizing is not only about a preferred Project, but also social meaning one values in their past experience. Juanmat has been actively involved in Open Science movement, which holds the political stance of science democratizing. Not only science should be open to the science community but also the general public. One of the political perspective can be reflected in one of the informal discussion he had with his design friends about science publication, in which he believes the publication and citation system has become a rate for scientists and some part of it has lost the meaning of communicating, especially communicating openly to a general public. He also inquire what the designers’ world is like and see if science can learn from the publication of the design world.

This political stance also emerges from his “evoking” and “applying”, when he criticize the scientific publication language of our time:

As a scientist, he understand science is complex, but the way science is presented to the public often appear to be so simple and even boring.

“We say that it is the DNA is like this, and that it makes the protein.. and forms Ebola, we say it in a way as if it is that simple, but it is not.”

...

But what is at the core of the problem? Juanmat point to the problem of research paper, which often takes a fixed structure of literature, method, experiment, results, etc., which is not how science is actually implemented. *“Science at lab is very messy, always in the cloud, we make a mistake, we throw away result...”*

The core of the problem, is how do we extract that? How do we present it? Should the outside know about it?

It is a yes for Juanmat. He believes the way we present our research should include incidence like daily dialogue like “Hey Rebecca, nice discovery!”. Science as a whole should be present, not just the results, in a hollow way. *“I imagine to have science paper as movies, so that people can really emphasize on what is really research in science”* (taken from fieldnote: B5.does science needs emotion)

Also, he evokes the NASA’s strategy is science communication, which he believes has a political purpose:

Juanmat then point out another side of the issue, the political side. He believed that some of NASA’s project is not only for science but also for public communication, e.g. looking for water on Mars. He thinks NASA need this publicity projects to get attention and funding, and on the other side the public also needs science. *“We now live in democracy and the public needs to know that science is important, and also science needs the public to understand it, to think about science, so it is a political issue.”* (from fieldnote: B3. what’s interdisciplinarity)

The political perspective of democratizing science is one of the prioritized meaning Juanmat applies consistently in daily life and in the workshop, as we have observed in the ethnographic observation.

Situated Prioritizing

The workshop format is an event with fluidity and accidental factors. Everything in the workshop, especially in a workshop where different background learners aggregate, is not planned rigid. The prioritizing, besides being inherent, has an situating side, which allow the prioritized project to change and evolve.

Situational factors can be partly attributed to the learner’s own incidental situation.

e.g. in one of the fieldnotes “labelling DNA content”, Juanmat explained he just wanted to think of something new, to get rid of the preconceptions.

Juanmat was the first to present his story. He wanted to think of something new, something outside bio-engineering with which he is so familiar. *“I want to get rid of all the preconception I have.”* He focus on

what he calls the “*social impact of scientific vocabulary*”, and particularly the concept of DNA. (fieldnotes taken from B6 labelling DNA content)

But in most cases, it can be attributed to the group dynamics. In the previous example where Juanmat and Pratek had two directions of prioritizing, Pratek was later convinced that the biological fact was not the priority. He started to actively . The situated reaction was attributed to Juanmat’s successful example of the science activism, which made Pratek to re-prioritize his original prioritized Project and Meaning, which is the biological fact about food nutrition.

Denqing’s bubble is another example of situated prioritizing. Before Denqing presented the very visualized music video, the group was focusing on the feasibility and practical use of the project. But Denqing’s example of the bubble is an unexpected situation to the group. In the later discussion group, although they still did not give up the practical side, they showed a comparatively equal role of the aesthetic consideration of the Project.

In general, the group accepted Denqing’s idea and believed his idea makes sense especially in terms of artistic presentation. But the group kept their concerns on the feasibility issue and a lot of the discussion was about this direction. But occasionally, when the group focus too much on the detail and get stuck, they are able to get back to the artistic part and found their way out taking this perspective. The group’s interaction slightly changed from “totally scientific” to a mixed status of both “keeping scientific” and “accepting romantic”.

....

There are also time when the group get stuck in the detail, and then question the whole idea. But instead of turning away as they did in their early discussion, the group will pick up the artistic and romantic side to complete the narrative and reconfirm it is meaningful. (fieldnotes taken from C4. Denqing’s bubble)

The final science fiction also demonstrate that their prioritized P/M at least include the artistic consideration, which should not have emerged without Daniqng’s input.

This intention lead to her proposal of a scenario very different from the previous discussion. She proposed a dark future where the entire world were polluted. And the only color they see in the air was the red alert of bubble.....The sci-fi ignite the group, everyone looks very happy with the story. “OK”, That’s it” They were all applauding for the story. The story was so attractive that people started to add more to it.

"Bitterly romantic!" Jinrong describes the sci-fi with the following: "it looks like romantic, but in fact it is an irony, the more color there is, the more bacteria there will be."

Scientific knowledge was also added to the final scenario: how the bubble will be degradable, easy to explode, without pollution. The group did not give up their many scientific details, but they started to attach the science part to the sci-fi story. (fieldnotes taken from C6. The science fiction)

10.3 Evoking, Applying, Prioritizing and Meaningfulness

In this section, we present the grounded theory of the construction of "Individual Meaningfulness" from the socio-cultural perspective.

The "Meaningfulness" represents what the learner recognizes as meaningful in the collaborative learning. In the socio-cognitive perspective, we understand that the individual meaningfulness concerns the Project-relevant meaning that the learner constructs, and it is related to the learner's past experience, e.g. disciplinary learning. We specifically study what constructs the "Meaningfulness" and how it is constructed from the socio-cultural perspective.

We use grounded theory to summarize the key codes that emerge in the "meaningfulness" construction, namely:

- "Evoking": the learner evokes a past experience/project that he or she believes relevant. The evoking establishes the relevance from the current Project to a past project.
- "Applying": the learner applies the evoked project to establish a similar meaning to the current project. The applying establishes a familiar meaning for the current project.
- "Prioritizing": the learner prioritizes what to evoke and apply based on his or her inherent preference and the specific situation. The prioritizing selects the most relevant from the many possible relevance one can evoke and apply.

The "evoking" and "applying" is a salient code, which commonly appears in our initial code in forms like "recalling experience", "giving example", "a youtube video" etc. It constructs the basic pattern of "Meaningfulness"

construction. In CoLAB, learner will often face the challenge that the current Project is often to some degree alien, not as easy to comprehend, or that his or her own proposition is to some degree alien to others, therefore requiring more explanation. That is why evoking and applying becomes very common. The learner will need to establish, communicate and ground the meaning through the “evoking” and “applying” process. The socio-historical Project allows the learner to approach the current project from a perspective he or she knew and the socio-cultural context provide a ground when they applies a similar meaning. The individual Meaningfulness is constructed in the meaning they apply.

The “prioritizing” pattern is however a relatively underlying code. With further comparative study, the “evoking” and “applying” is proved to have a multiple potential, meaning not only one project or one meaning can be evoked and applied given the specific Project at hand and the specific learner. What the learner actually chooses to evoke and apply is subject to a prioritizing process. Because the prioritizing concerns P/M that does not explicitly appear, it is not as common as we can observe for the basic pattern. We use codes such as “oppressed P/M” to extract and explain the phenomenon. Though underlying, the “prioritizing” is important because it reveals the deeper connection between the learner’s socio-historical background and the meaningfulness her or she constructs in the learning. The historical background serves two roles in meaningfulness: 1. It consists a pool of potentially evocable Project and applicable meaning, 2. It is also a network that determines which project and meaning to prioritize in the “evoking” and “applying” process. The prioritizing pattern is found to be both inherent and situated. It is inherent because the network is built before the learning and many of the prioritized project and meaning remains their high priority. It is also situated because the network is flexible, it is subject to changes and situational actions of the learner, their peers as well as environmental factors.

“Meaningfulness”, as our most essential concept, can now be associated with its socio-cultural perspective from the three codes:

1. “Meaningfulness” presents what the learner recognize as meaningful in the “meaning” he or she applies from an evoked “Project”.
2. “Meaningfulness” presents what the learner recognize as meaningful in prioritizing the “Project” and “Meaning” from the other potential options.

To conclude the socio-cultural perspective of the “Meaningfulness”, we will complete the code we made in the socio-cognitive perspective about the project relevant “Meaningfulness”: the P-M Intensity. It is important to integrate the different perspectives of “Meaningfulness” to make a comprehensive understanding.

Chapter 11. Evoking, Applying and Prioritizing and the Co-Meaningfulness Trajectory

In the socio-cognitive perspective, we define Co-Meaningfulness as the project-related, collective and developing status of “Meaningfulness”. From the socio-cultural perspective, the Chapter 9 and 10 have extensively analyzed the “project-related” aspect of the Co-Meaningfulness: that the project-relevance is manifested in the combination of “Evoking” “Applying” and “Prioritizing” process. Co-Meaningfulness is the collective state of Meaningfulness and it is developing as the project evolves. From the Chapter 9 and 10, we understand that it is not only concerned with the current project and possible associated meaning, but also concerned with: 1. Socio-historical Project evoked to established relevance 2. Socio-cultural Meaning associated with the evoked project 3. A network of Potential P/M to prioritize from.

Therefore the Co-Meaningfulness encompasses a more complex network of P/M and their relationships in the socio-cultural perspective. The learners not only ground their understanding of the current Project and Meaning, but also the evoking and applying of past experiences, which ultimately extend to a underlying network of P/M and the prioritizing process. Mutual communication can happen at all levels: they may communicate on the relevance of the past P/M and the current, or negotiate at the prioritizing level. The heterogeneity of Co-Meaningfulness is manifold, in the different “Projects” they evoke, in the different “Meaning” they apply, in the different prioritizing they adopt, as well as the different underlying socio-historical background and socio-cultural context (illustrated in the Fig. 11.1).

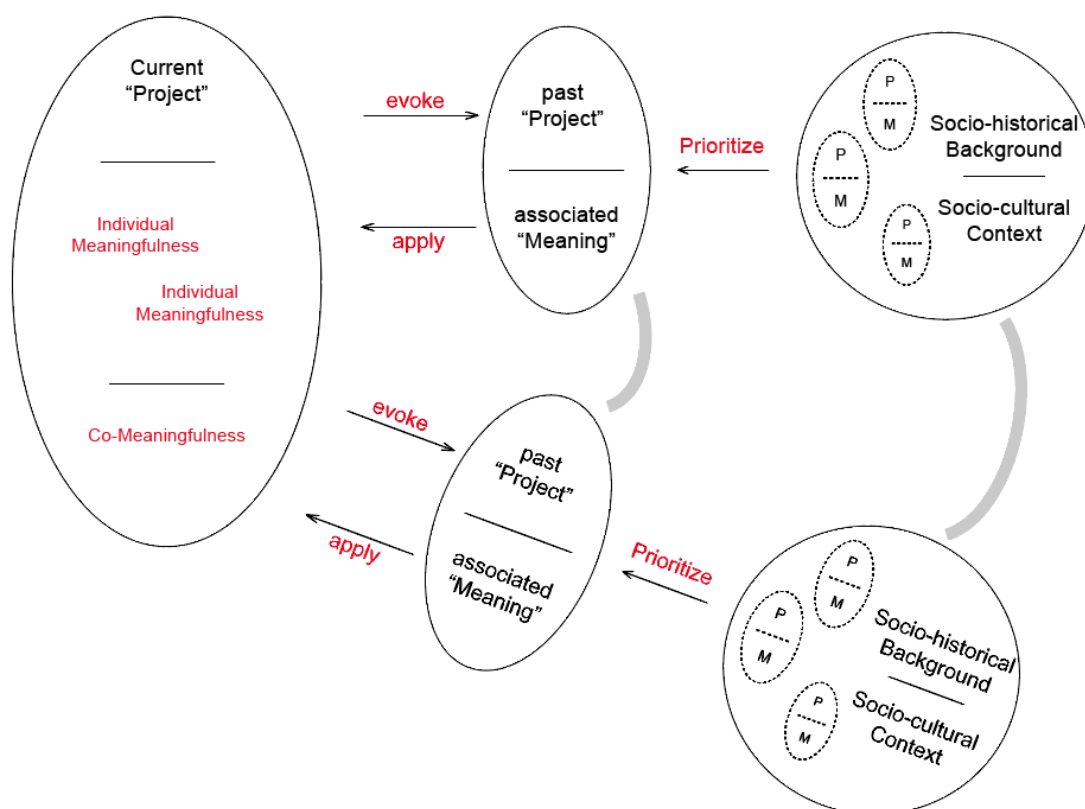


Fig. 11.1 Constructing “Co-Meaningfulness” from multiple “Meaningfulness”

Despite being complex, the Co-Meaningfulness has a vast potential in this perspective. The learners co-construct a large network of potential P/M with each of their socio-historical background and social context. It becomes an open space, in which learners can contribute their knowledge, past Project as well as how they understand, prioritize the different P/M. The job of group is to establish their coherent and vigorous Co-Meaningfulness from this vast potential.

The multi-level heterogeneity of Co-Meaningfulness provide us a 3-level framework to study the Co-Meaningfulness from a socio-cultural perspective. In the previous PART, we have concluded two essential properties of Co-Meaningfulness, i.e. “M-M Coherence” and “P-M Intensity”. And in this PART, we will use the threefold framework to further study Co-Meaningfulness. The table and figure below (Table 11.1, Fig 11.2) presents the questions we summarize for the two properties of Co-Meaningfulness.

Levels	P-M Intensity	M-M Coherence
Evoking	1. Does the learner present the evoked project? How well?	
	2. Does the group understand the evoked the project and its	

	relevance to the current Project? How well?	
		3. Does the group agree on the relevance of the evoked project?
Applying	4. Does the learner present the applied meaning? How well does he or she present ?	
	5. Does the group understand the meaning applied and its relevance to the current Project? How well?	
		6. Does the group agree on the relevance of the applied meaning?
Prioritizing	7. Can the learner evoke and apply P/M that he or she prioritize?	
		8. Does the group agree on the prioritizing?

Table 11.1 Questions for the three levels of Co-Meaningfulness

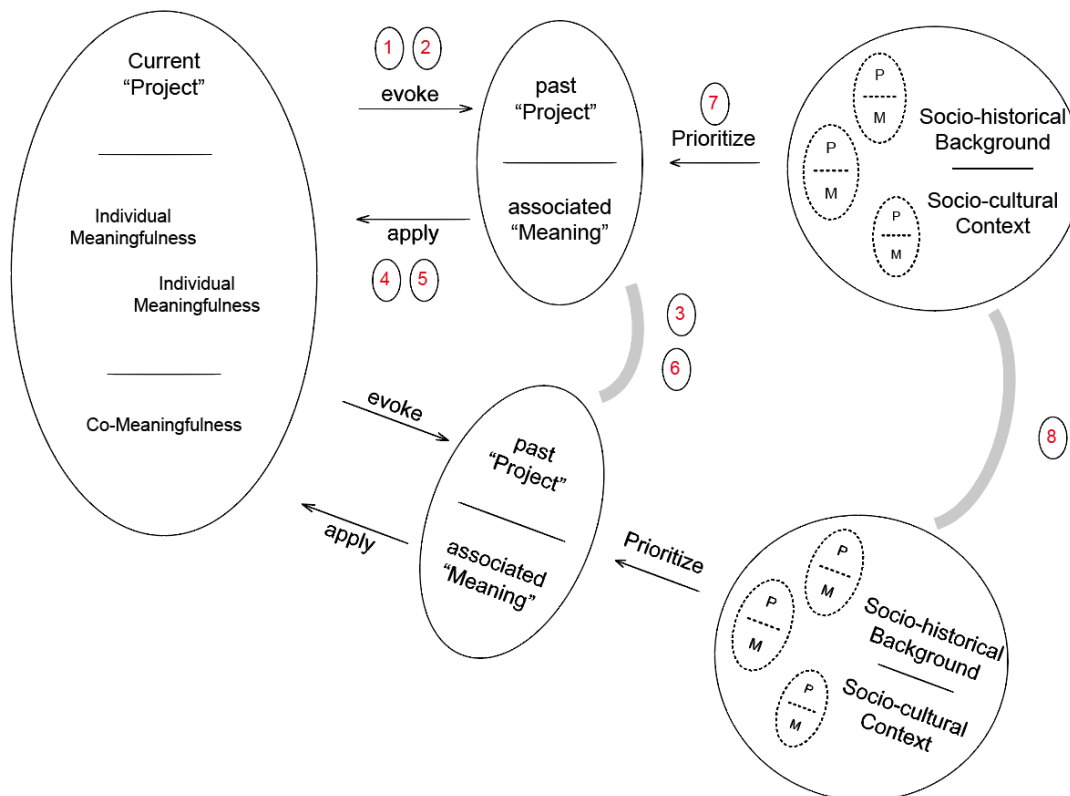


Fig 11.2 Questions for the three-level framework of Co-Meaningfulness by Index

These questions set up the framework for theorizing Co-Meaningfulness quadrant and trajectories in both socio-cognitive and socio-cultural perspectives, which we will present in section 11.1. The framework (table 16.1) also serves as the grounded frame that guides the coding for the “Co-Meaningfulness” trajectory.

11.1 Three levels of Co-Meaningfulness and its properties

In the socio-cognitive perspective, we have generated the two important properties for the concept “Co-Meaningfulness”, which is the “P-M Intensity” and “M-M Coherence”. In this chapter, as we have generate the key codes for the socio-cultural perspective, we will now combine the both perspectives and understand Co-Meaningfulness in a hybrid way.

We develop a 3-level framework for understanding the Co-Meaningfulness. The framework consists in total 8 categories of the different perspective of Co-Meaningfulness and the purpose of setting up these categories is for building a framework that we can use to code the different learning scenarios and analyze them in respect to the socio-cognitive and socio-cultural perspective of Co-Meaningfulness.

The Evoking-Level

As we have presented, the process of evoking is common in the CoLAB learning. Learners very often evokes their personal historical “Project” that he or she believes relevant to the current Project. The relevance is essential in determining what the learners want for the current “Project”, either to modify, to understand or to explain it. This relevance is built by the learners themselves with their own experience and will need to be integrated into the “Co-Meaningfulness” of the group.

However, in CoLAB, as different learners might have a divergent socio-historical background, the introduction of a certain “Project” into the “Co-Meaningfulness” might not be as efficient as the learner might suppose. Will the learner well present the evoked “Project”? Will the “Project” be understandable to others? Will the group agree on relevance of the “Project” that one of them provoke? The First two questions concerns the P-M Intensity whereas the last one concerns the M-M Coherence.

1. Present Evoking

Does the learner present his or her evoked project? If so, how well does he or she present?

This is the first question to ask when we try to analyze the P-M Intensity. A good presentation will successfully bring the evoked project into the space of joint discussion, which is the premise of further understanding and agreeing on the evoking. While an unsuccessful presentation will probably lead to confusion, misunderstanding and hence the difficulty in constructing the Co-Meaningfulness.

2. Understand Evoking

Once the evoked project is presented, does the group understand the Project and its relevance to the current Project? In CoLAB, because of the heterogeneous background, there is no guarantee a presented Project will be immediately understood by the group, even if it is presented accurately. An engineer might miss some key information or terminology when presented with a design project, and vice versa. Therefore, the accurate understanding of the evoked project and its relevance as it is established by the learner who proposes it is another important factor of the P-M Intensity.

In most cases, the degree of understanding is not obvious to distinguish. But we can still infer from the conversation analysis and relying on the analysis of grounding technique, such as noticing the positive and negative turn taking. When we lack the conversation data, we can use research fieldnotes and post-interviews to code and distinguish.

3. Agree Evoking

Does the group agree on the relevance one builds between the evoked project and the current project? In CoLAB, the answer is not necessarily positive. One might understand differently and reject the relevance or build alternative relevance. Disagreeing on the evoking often happens when the group members debate on the functionality level, which may or may not concern the underlying social meaning difference.

The Applying-Level

The purpose of evoking a Project is normally to apply the social meaning associated with it to the current Project. But again, the social meaning is not necessarily well presented, understood or agreed. In CoLAB, an evoked Project can have divergent reading in terms of its social meaning.

What meaning does the learner make when they first experienced the project? Why do they apply the meaning to the current Project? Questions like

this will not be systematically discussed as the time for making the project is limited. Therefore the meaning is often communicated through grounding. And sometimes learners take it for granted that meaning will be automatically understood and agreed, which however is not the real situation. Co-Meaningfulness at the applying-level concerns the collective states of social meaning applied to the current project.

4. Present Applying

One way to communicate the social meaning being applied is to directly present it. Sometimes, people do not realize that they need to present it directly therefore it creates a myth for the evoked project and its associated meaning in the group. When presented well with evoked project, the meaning can be well introduced to the Co-Meaningfulness easily. But in many cases, time is limited, and the pace of discussing is intense. There is no room for thorough presentation of the meaning. In these cases, good presentation, unclear presentation, or even no presentation at all will differentiate in terms of the P-M Intensity.

5. Understand Applying

Whether the meaning is presented or implied, the learner who proposes and communicates it wants it to be understood and applied by the group. The social meaning can be understood because the socio-cultural context of different learners has overlap. Even for disciplinary knowledge, there is a grounded understanding of its social meaning as we live in this entangled society. But how much the other learners understand the meaning depends in different situations. Again we can use conversational analysis and ethnographic data to interpret the degree of understanding.

6. Agree Applying

Do learners agree on the meaning applied to current Project? Many debates happen at this level. It is essentially a problem of how different learner makes meaning. When learners of different background gathers, they are even more likely to have these kinds of disagreement.

The Prioritizing-Level

The third level of Co-Meaningfulness is the prioritizing level. To understand how learners prioritize, one needs to only understand the conversation or interaction, but also to understand well enough about the learners. Who are the learners? What are their interests? Why do they perceive some P/M more prioritized to others?

7. Present Prioritizing

A learner can choose to compromise their own prioritized Project and Meaning for multiple reasons: e.g. time limits, the group dynamic, being interrupted, or feeling discouraged, etc. Whether the learners present the prioritized P/M is one important mark of P-M Intensity. Presentation with strong motivation indicates a vigorous P-M Intensity, while oppressed presentation or no presentation indicates an inert state.

It is however not easy to tell if someone is presenting or hiding their prioritized P/M. We have to understand the intrinsic motivation of the learner as well as their status in the workshop. In order to determine the present Prioritizing level, only socio-cognitive analysis is not enough. We need to combine socio-cultural perspective in our ethnographic study.

8. Agree Prioritizing

The final aspect of the three-level framework of Co-Meaningfulness is whether different learners agree on a specific P/M should be prioritized. In situations where learners agree that the evoked project is relevant, and the associated meaning is eligible, there still can be different stances upon whether the P/M is trivial or significant.

11.2 Generating Co-Meaningfulness Trajectory with the Three-level Framework

The “Co-Meaningfulness” concept was generated through grounded theory with the socio-cognitive perspective. It serves as an analytical tool for understanding the underlying mechanism of CoLAB learning as well as a framework to categorize the different states of CoLAB learning. The different states can be identified with the two properties we generate: P-M Intensity and M-M Coherence, with the former indicating how intensive learners engage their Meaningfulness in the CoLAB learning and the later indicating how coherent the collective state of Co-Meaningfulness is.

With the socio-cultural perspective, the “Co-Meaningfulness” is more complete. It casts light to the Meaningfulness with respect to learners’ socio-historical background and socio-cultural context. The Meaningfulness is regarded as an integration of Prioritized “Evoked” Project and “Applied” Meaning. We combine the socio-cognitive perspective and the socio-cultural perspective and generate a three-level framework that comprehensively categorizes the “Co-Meaningfulness” states. This final framework is a grounded theory result from the initial coding, focused coding and theorizing.

With a constructive grounded theory, the researcher's choice of the essential codes are crucial in generating the theory. In our theory, the code of "P-M Intensity" and "M-M Coherence" as well as "Prioritizing" "Evoking" "Applying" set up the basic categories. Besides these codes, there is also an important underlying "code" we choose in order to make the categories more understandable and useful. The special "code" is the Co-Meaningfulness quadrant map in the form of visual presentation. As both researcher and practitioner, we understand it is as important to make the analytical tool as to communicate and apply it. The quadrant map can help practitioner understand CoLAB process and their development in a sensible and visible way, which is another purpose of the research. In this section, we will apply this tool with more cases of the co-lab workshops. In addition to the example we demonstrated in the socio-cognitive perspective, we will exemplify how this framework can be used under the three level framework.

The way to use it is to make focused coding with respect to the three-level framework, e.g. code for the process that marks a good presentation of evoking that improves the P-M Intensity, or the a misunderstanding of the meaning applied. After the focused coding, we can use the quadrant map to visualize the different states. The visualization is an interpretation of the researchers' comparing of the different states, which has only a qualitative meaning.

The following table and figure (Table 11.2 and Fig. 11.3) are one example of using the framework for generating Co-Meaningfulness trajectory.

			1.Juliette evokes an interdisciplinary field	2.Christian's ecology	3.Christian's living object
P/M intensity					
1	Evoking	present		[+] visualized presenting	
2		understand			[+] valid and iterative response
4	Applying	present	[-] not so much explaining on the meaning		[+] meaning presenting with interaction design analogy
5		understand			
7	Prioritizing	present	[++] Juliette actively presents her prioritizing topic	[+] Ke actively presents his prioritizing project	
M/M Coherence					
3	Evoking	agree			
6	Applying	agree		[-] Ke made a detour of meaning	
8	Prioritizing	agree			[+] prior interests of living object agreed

Table 11.2 Example of Co-Meaningfulness trajectory coding of B1.

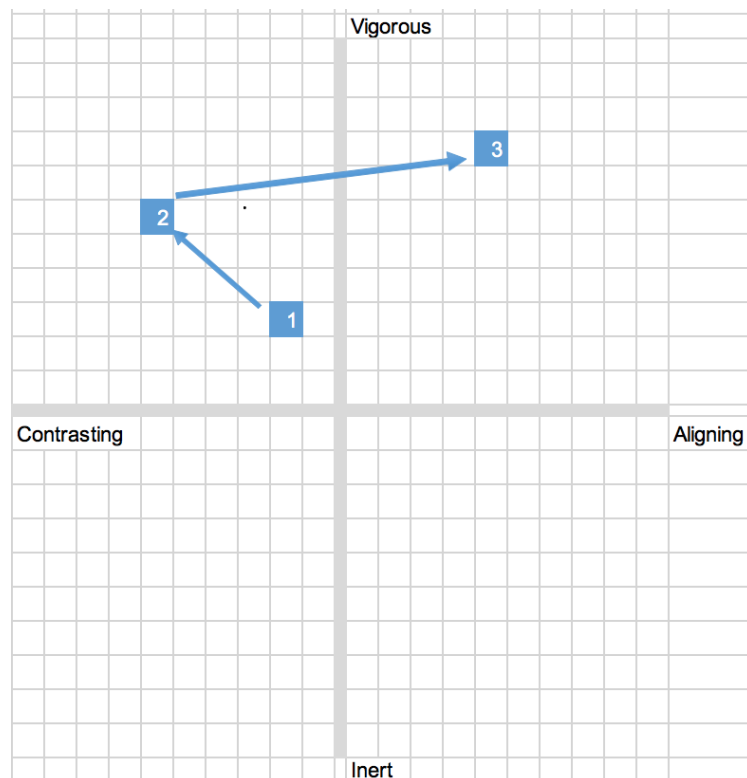


Fig. 11.3 Example of Co-Meaningfulness trajectory of B1.

We propose the following steps to use the Co-Meaningfulness trajectory for researcher/practitioner to reflect and analyze their CoLAB process:

Step 1. Initial coding to get familiar with the data and extract the initial categories of analytical power

Step 2. Focused coding to extract key interpretation of the learning process with respect to the three-level framework. For example, in the Table 11.2 “Not so much explaining on the meaning” is one focused code extracted from the Applying-Present category.

Step 3. Review and compare the different codes and determine the different states. For example, the “Not so much explaining on the meaning” and “Juli actively presents her prioritizing topic” are clustered into one episode “Juli evokes an interdisciplinary field”

Step 4. Further compare the different states and coding and determine the qualitative degree of P-M Intensity and M-M Coherence, and draw the Co-Meaningfulness trajectory.

Step 5. Further analyze the process based on the key turns of the trajectory.

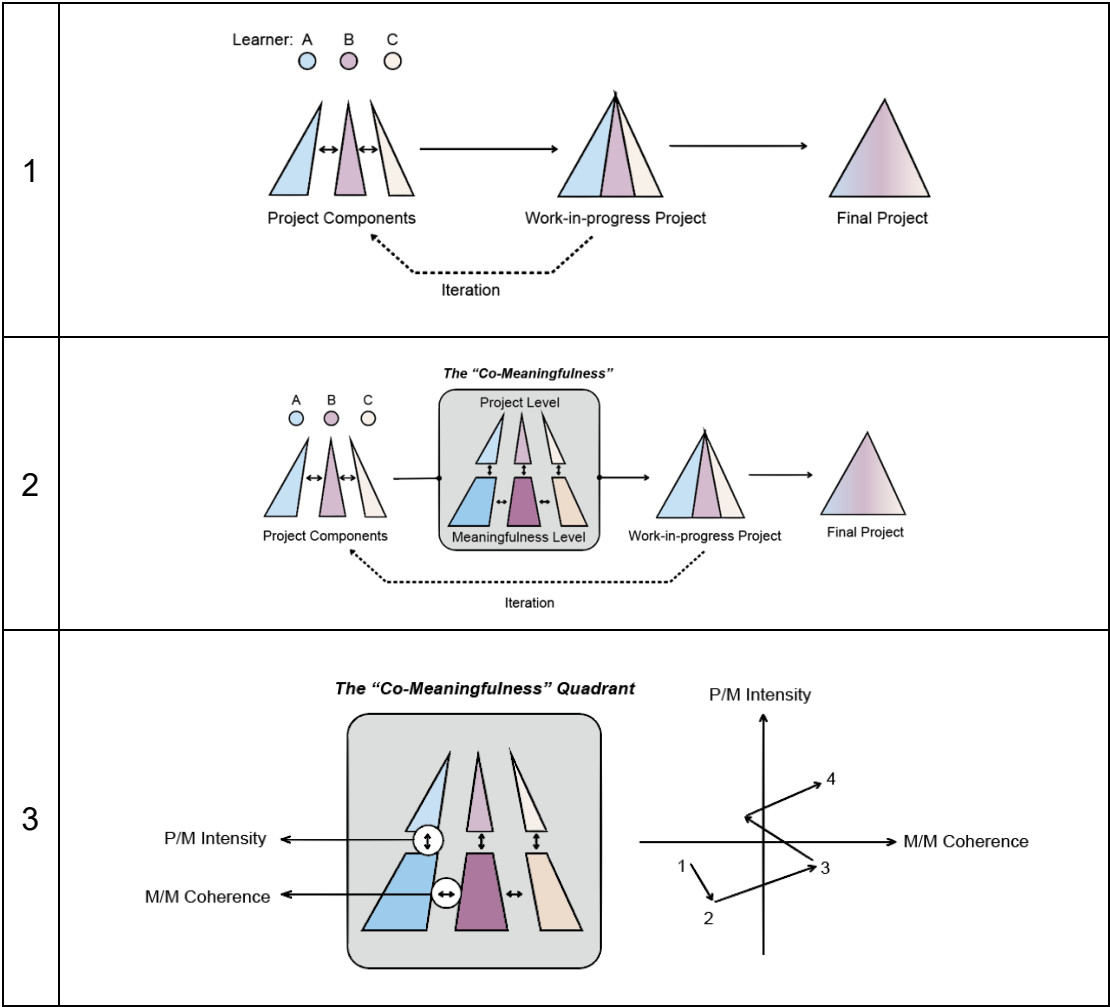
With the three level of framework, the practitioners can effectively review their practice in a structured way without losing their acute observation and deep understanding of the process, because the coding and analyzing are essentially the practitioner’s own interpretation rather than a provided coding system. At the same time the structured framework help the practitioners to focus on the “Co-Meaningfulness” construction at different levels in both socio-cognitive perspective and socio-cultural perspective. Finally the Co-Meaningfulness trajectory which integrates all the comparative analysis is easy to understand and present as a visual tool. It highlights the different states of CoLAB process and its key turns which researchers/practitioners should pay attention. To see more examples of Co-Meaningfulness trajectory generated from the above approach, please refer to APPENDIX D.

Coding for the Co-Meaningfulness trajectory also demonstrates the developing nature of “Co-Meaningfulness” in the socio-cultural perspective. Constructing Co-Meaningfulness in the socio-cultural perspective means that the learners will need to constantly re-evoke, re-apply and re-prioritize in order to reach a high level of P-M Intensity and M-M Coherence(see re-evoking, re-apply and re-prioritizing in the different focused coding of Table 11.2 and other examples in APPENDIX D). The constant re-evoking, re-applying and re-prioritizing invites more “Project” and “Meaning” from the potential P/M network of the learners to construct the Project and Co-Meaningfulness. The final “Project” and “Co-Meaningfulness” will also enter the learners’ socio-historical network of P/M for him or her to evoke, apply and prioritize in the next CoLAB. The socio-cultural perspective of Co-Meaningfulness connects the CoLAB process to the learners’ socio-historical learning as well as their development in continuous CoLAB learning and cultivation. This

developmental perspective of CoLAB will be discussed further in the final part of Conclusions.

Chapter 12. Conclusion: the Grounded Theory of Co-Meaningfulness

In this chapter, we will conclude the grounded theory of “Co-Meaningfulness”, which is the key result of this thesis. As grounded theorizing is a structured and dynamic process, we would like to review both the grounded theory result, as well as the process through which we develop it. In the following illustration (Table. 12.1), we present the key steps of the entire development of “Co-Meaningfulness” with a consistent visualization of the framework. The first three steps are based on the socio-cognitive perspective, while step 4 to 6 are based on the socio-cultural perspective.



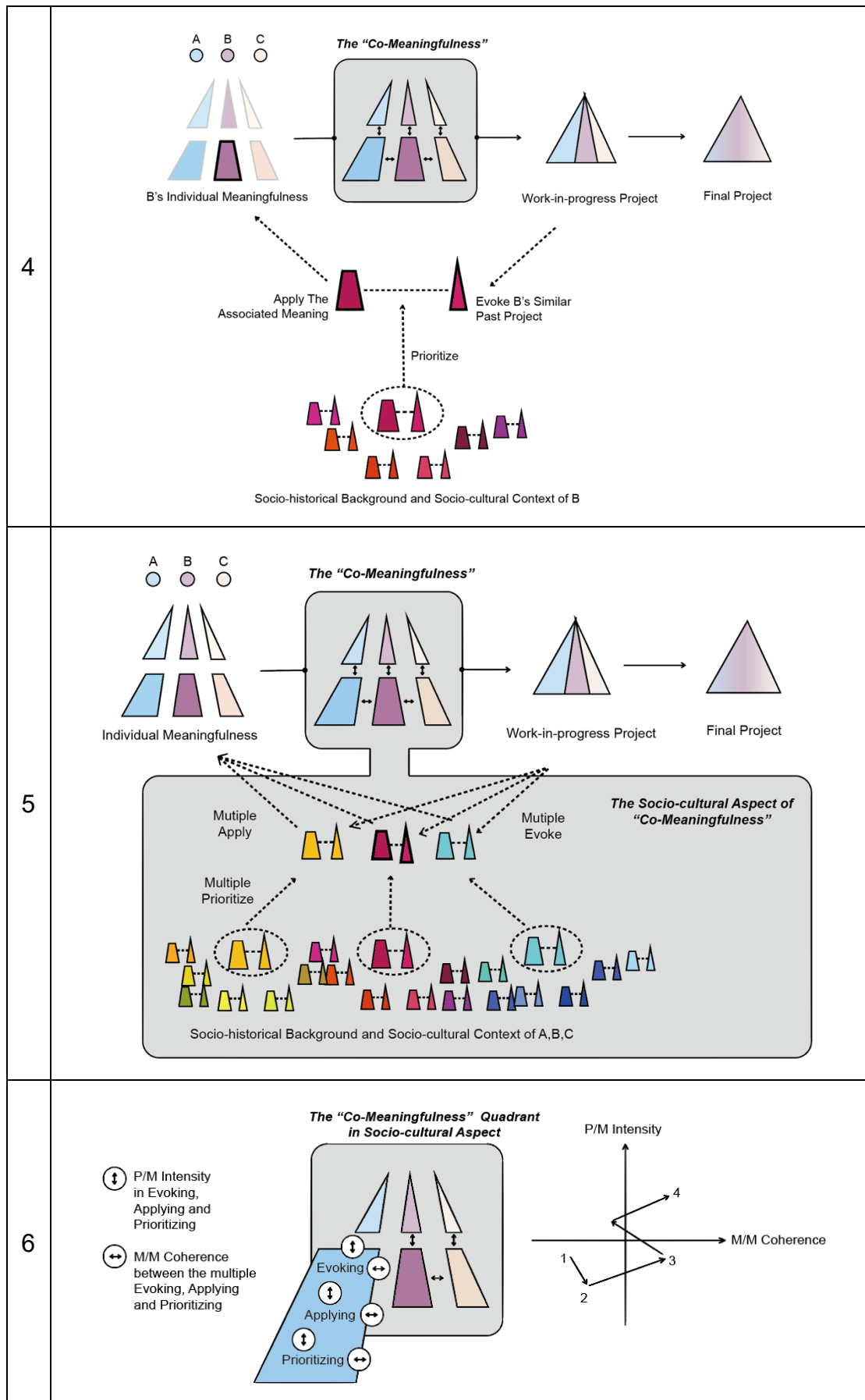


Table 12.1 Visualization of the 6 Key Steps of the Grounded Theory of “Co-Meaningfulness”

Each step of the grounded theorizing process adds to the comprehensiveness and depth of the theory, by iterative and sustained inquiry, purposive sampling, theoretical sampling, coding, categorizing, and conceptualizing. The following explains the 6 steps illustrated above.

12.1 The Socio-cognitive Perspective of Co-Meaningfulness

Step 1: Project Components, Work-in-process “Project”, and the iterative process.

In CoLAB, the basic form of learning is through collaboratively constructing a project that addresses the open wicked problem. The learning process is associated with the maturing of that project. In the initial coding (first step of grounded theory, coding data extensively to extract the preliminary analytical meaning of data), “Project” emerged as a key code in the form of “Project Components”, e.g. a certain function one learner wants to add to the “Project”. Different “Project Components” proposed by different learners set up the initial “Project” space, from which the learners will need to assemble an agreed and consistent “Project” at the end. However, the process of constructing the “Project” is not linear: when the intermediate and very often imperfect “Work-in-progress Project” causes disagreement and conflicting opinions, the learners will iterate to add, modify, or remove part (or, in extreme situations, all) of the “Project Components”. This non-linear iteration often marks the important moments of CoLAB learning, when learners need to resolve the conflict ideas of the “Project”.

In the following visualization (Table 12.2), we use three small round to represent the three learners (each with a distinct color). The triangles below them represent their proposed project components, the work-in-progress project is presented by the components put together, but as they might cause problems, the work-in-progress Project might lead to iteration. The final project is in blended color meaning the different components finally merge.

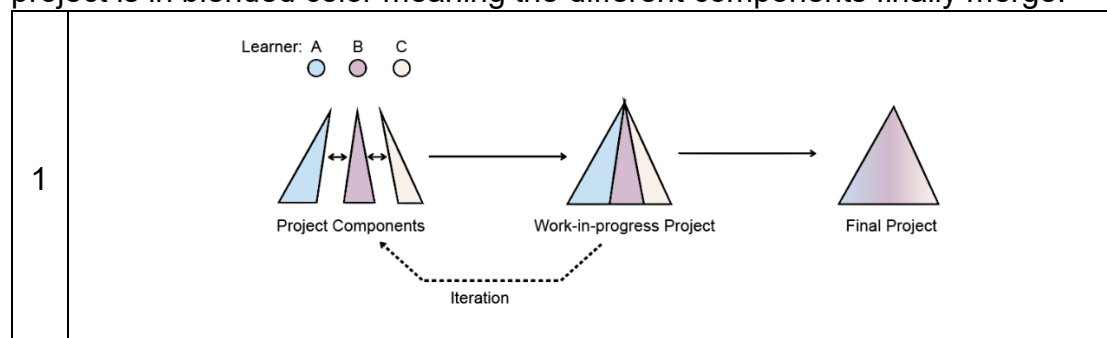


Table 12.2 Visualization of the Step 1 of the Grounded Theory of “Co-Meaningfulness”

Step 2: The underlying driven force of “Meaningfulness” and the emergence of “Co-Meaningfulness”.

The initial coding of the iterative process presents another key code: “Meaningfulness”, particularly at the moments when learners have to resolve the conflicting views on the “Project Components”. In our case study(PART IV), although the design student and engineering student are discussing on the same “work-in-progress” project (an automatic camera), their focuses are different. The design student wants to focus on the interaction between the person being photographed and the camera, while the engineering student wants to focus on the specific lighting effect the camera can trigger. The conflict gradually leads to a discussion on why and how they believe the project is meaningful, which unveils the ultimate divergence between the two. The designer thinks an conceptual association and interaction between human and machine is meaningful, while the engineer believes inventing an original effect is the essential meaning of their project.

With purposive sampling of several other alike key moments, we are able to find that the “meaningfulness” plays a key role in driving the “work-in-progress” Project, especially when learners have difficulties in front of the “Project” conflicts. With further analysis, we summarize three key aspects of “Meaningfulness” for it to impact the “Project”: first, Meaningfulness is not independent but associated with the “project”; second, the collective status of “Meaningfulness” matters; third, the “Meaningfulness” has the potential to develop in the learning process. We therefore define this “project-relevant”, “collective”, and “developing” status of “Meaningfulness” as “Co-Meaningfulness”. The Co-Meaningfulness emerges as the key drive for the project building and learning process, as the conflicts between “Project Components” reside not only at the project level, but also at the Meaningfulness level, both in the different meaningfulness learns hold and their different approaches in engaging their meaningfulness in the project.

It is important to note that this definition of Co-Meaningfulness sets up the initial direction of our grounded theory. But it is far from a comprehensive and mature category or concept at this stage. As we develop our grounded theory, the “Project-relevant”, “collective” and “developing” aspects will be developed iteratively through comparative analysis of more data and coding. But we deem it is important to define Co-Meaningfulness here. First, we need a name for this underlying driving force, and “Meaningfulness” alone is not sufficient, especially for the “collective” feature. Second, the “Co-Meaningfulness” defines the key focused categories that foreshadow our grounded theory. In the constructivist grounded theory, the researcher iteratively selects key

coding as categories, compare them with more data and coding to develop the grounded theory. With this purpose, the “Co-Meaningfulness” is the pivotal category that guides our further analysis.

In the following visualization, the step from Project components to work-in-progress is inserted by a “Co-Meaningfulness” box where the quadrilateral below the triangles present the “Meaningfulness”. The underlying process of Co-Meaningfulness is presented by the inserted box. The double arrows in the box indicate the “project-relevant” and “collective” aspect of Co-Meaningfulness.

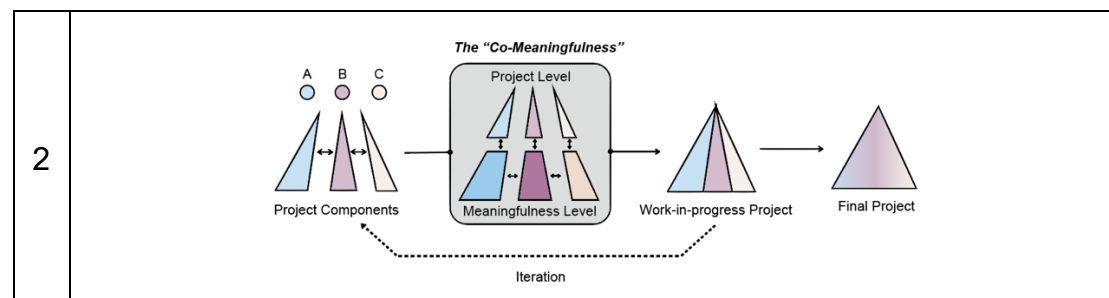


Table 12.3 Visualization of the Step 2 of the Grounded Theory of “Co-Meaningfulness”

Step 3: P-M Intensity (Project-Meaningfulness Intensity), M-M Coherence (Meaningfulness-Meaningfulness Coherence), the Co-Meaningfulness Quadrant and Trajectory .

With theoretical sampling (meaning further sampling for more data with the purpose to complete certain theoretical direction in grounded theory, see PART III for more details) into more data and coding, two key properties of Co-Meaningfulness are selected : the P-M Intensity (Project-Meaningfulness Intensity) and M-M Coherence (Meaningfulness-Meaningfulness Coherence). P-M Intensity indicates the degree to which learners actively and effectively engage their individual meaningfulness in the project, while the M-M Coherence indicates the relationship between different individual meaningfulness: whether they are contradicting to each other, supportive to each other or completely aligning. The P-M Intensity concerns the “Project-relevant” aspect of “Co-Meaningfulness” whereas the M-M Coherence concerns the “collective status” of Co-Meaningfulness. The two dimensions of Co-Meaningfulness construct the Co-Meaningfulness Quadrant where the trajectory of CoLAB learning process can be anchored. The trajectory is both an analytical tool for researchers and a reflective tool for learners and practitioners to review the good and bad practices in their learning. The Co-Meaningfulness Quadrant and Trajectory is a special visual coding to relate and integrate the different properties of Co-Meaningfulness – the two dimensions presents the P-M Intensity and M-M Coherence and the trajectory presents the development of Co-Meaningfulness. The generation of the Co-

Meaningfulness Quadrant and Trajectory is the most essential in our grounded theory as it serves as a pivotal role in relating different concepts and categories.

In the following visualization, the P-M intensity is presented by the double arrow between the triangle (Project) and the quadrilateral (Meaningfulness) whereas the M-M Coherence is presented by the double arrow between different quadrilaterals. The Co-Meaningfulness trajectory is presented in the quadrant on the right.

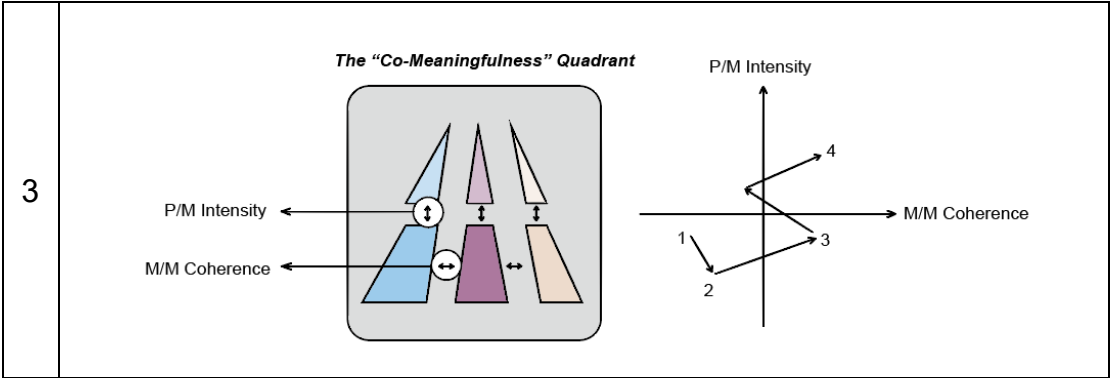


Table 12.4 Visualization of the Step 3 of the Grounded Theory of “Co-Meaningfulness”

12.2 The Socio-cultural Perspective of Co-Meaningfulness

Step 4: Where does Meaningfulness come from: The basic pattern of Evoking and Applying, and the underlying pattern of Prioritizing.

The step 4 grounded theory answers the basic question concerning “Meaningfulness”: what is it and where does it come from. With further theoretical sampling, we generate three focused codes in explaining the individual “Meaningfulness” in CoLAB: namely the basic pattern of “Evoking” and “Applying” and the underlying pattern of “Prioritizing”. The “Meaningfulness” is not a deliberate creation for the “Project” per se., but deeply associated with the learner’s socio-historical experience and socio-cultural context. The work-in-process project evokes the learner’s past related experience and associated social meaning which the learner applies to the current project. Through the process of “Evoking” and “Applying”, which are two very salient codes in the initial coding, the learner builds their individual meaningfulness. With further scrutinizing and comparing the data and codes, the underlying but significant code “prioritizing” emerges: there is not necessarily just one past project and one associated meaning to evoke and apply, and the final meaningfulness is the result of prioritizing the most relevant P/M, according to the learner’s intrinsic priority and the situational and environmental factors of the learning scenario. The focused code of “Evoking”, “Applying” and “Prioritizing” cast light to “Meaningfulness” by

connecting it to the socio-historical and socio-cultural perspective of the CoLAB.

From step 4 on, we switch to a socio-cultural perspective. Although “Meaningfulness” initially emerges as a focused code from the socio-cognitive perspective, its deep meaning inevitably concerns the socio-cultural aspect, which is not neglectable in understanding Co-Meaningfulness in CoLAB.

In the follow visualization, a similar color (red) triangle and quadrilateral are used to represent the related Project and Meaning of B, with which B evokes and applies to the Project and get his or her Meaningfulness(purple) for the current project. The pair of the red triangle and quadrilateral are prioritized from the pool below them, where many other potential triangles and quadrilaterals of B exist.

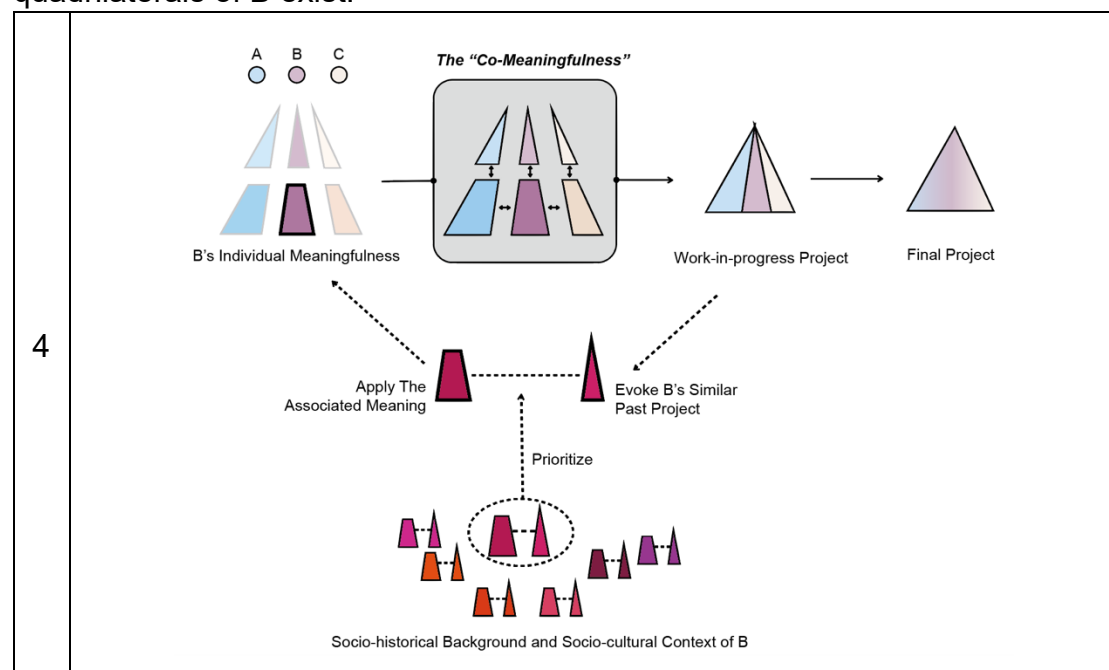


Table 12.5 Visualization of the Step 4 of the Grounded Theory of “Co-Meaningfulness”

Step 5: The Socio-cultural Aspect of Co-Meaningfulness: multiple Evoking, Applying and Prioritizing.

The Co-Meaningfulness is a result of multiple Evoking, Applying and Prioritizing. The internal tension of Co-Meaningfulness is then understood as the tension between different Evoking, Applying and Prioritizing. Further theoretical sample of data and coding spotlights the key moments when “Co-Meaningfulness” develops as the learners develop their evoking, applying and finally to re-prioritize. Learning across boundaries happens when learners can understand and appreciate an alternative evoking, applying and prioritizing, and internalize the new evoking, applying and prioritizing in the project at hand.

In the following visualization, we see the Co-Meaningfulness box is extended to a multiple evoking, applying and prioritizing of different triangles (Projects) and quadrilaterals (Meaning) to present the Co-Meaningfulness in the socio-cultural aspect.

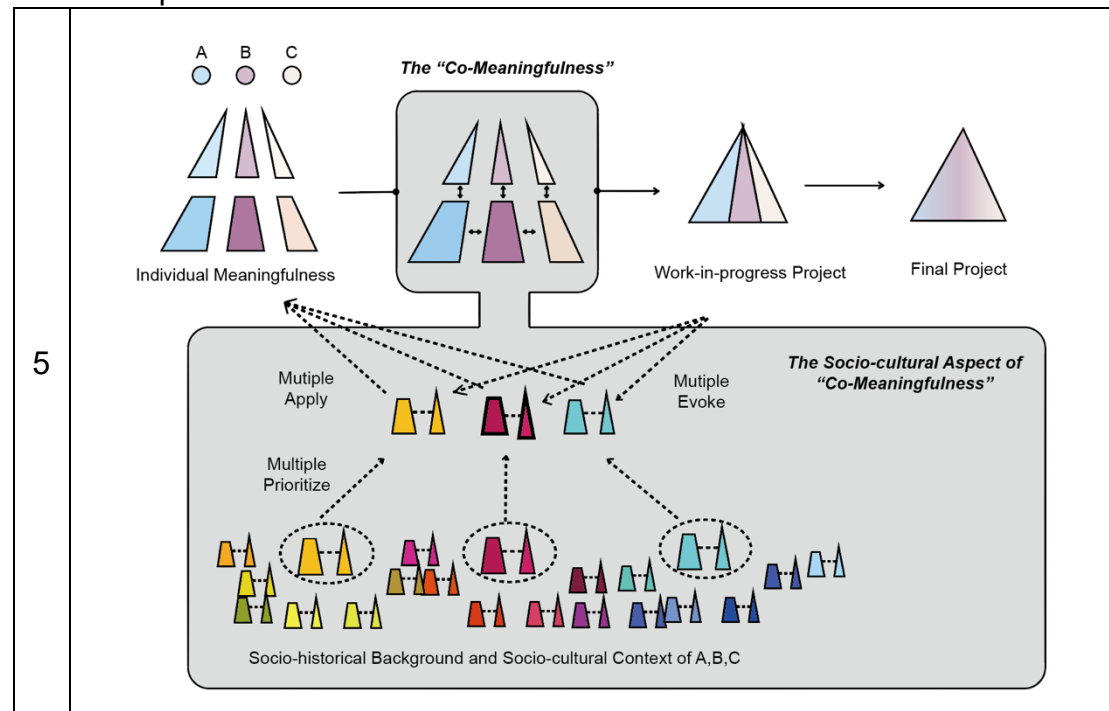


Table 12.6 Visualization of the Step 5 of the Grounded Theory of “Co-Meaningfulness”

Step 6: Advancing the Co-Meaningfulness Quadrant and Trajectory with the Socio-cultural Perspective.

The final step of our grounded theory couples the socio-cognitive and socio-cultural perspectives. The P-M Intensity in this sense means how active and effective the learners engage their evoking, applying and prioritizing, while the M-M Coherence means how coherent it is between different learners in their evoking, applying and prioritizing. The final theorizing builds an evaluation matrix for the Co-Meaningfulness trajectory as follows:

Levels	P-M Intensity	M-M Coherence
Evoking	1. Does the learner present the evoked project? How well?	
	2. Does the group understand the evoked the project and its relevance to the current Project? How well?	
		3. Does the group agree on the relevance of the evoked project?

Applying	4. Does the learner present the applied meaning? How well does he or she present ?	
	5. Does the group understand the meaning applied and its relevance to the current Project? How well?	
		6. Does the group agree on the relevance of the applied meaning?
Prioritizing	7. Can the learner evoke and apply P/M that he or she prioritize?	
		8. Does the group agree on the prioritizing?

Table 12.7 Evaluation matrix for P-M Intensity and M-M Coherence relative to Evoking, Applying and Prioritizing

In the following visualization, the double arrows still represent the P-M Intensity and M-M Coherence. The P-M Intensity arrows are now connecting “evoking”, “applying” and “prioritizing” from the quadrilateral to the triangle, whereas the M-M Coherence arrows are now comparing between “evoking”, “applying” and “prioritizing” between the different quadrilaterals.

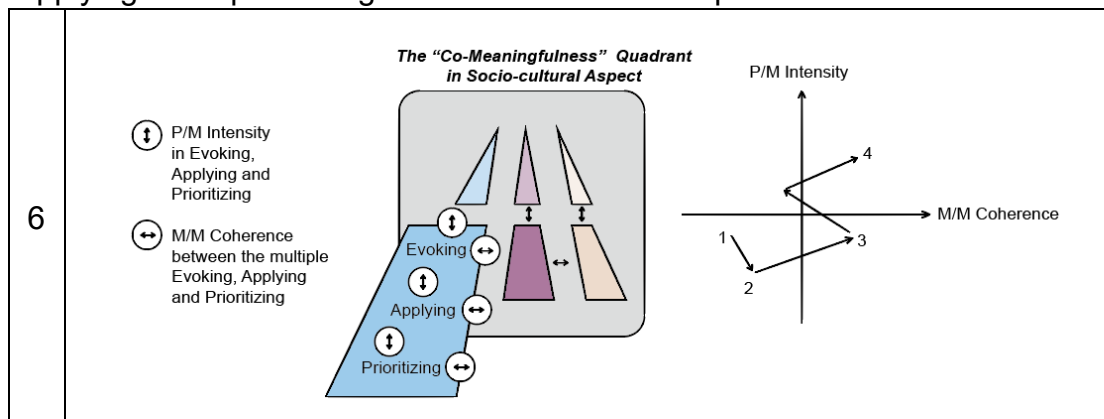


Table 12.8 Visualization of the Step 6 of the Grounded Theory of “Co-Meaningfulness”

The whole process of the grounded theory of consistent with an internal logic to fit our motivation of this thesis, which is to understand CoLAB with practical lens and to build pragmatic tools for practitioners.

CONCLUSIONS

1. Thesis Summary: Constructing Co-Meaningfulness in

CoLAB

This thesis is a grounded theory study of the new learning model of CoLAB. The CoLAB (Collaborative Learning Across Boundaries) model emerges in the era of Open Wicked Problems - problems that are ill-defined, resisting single optimization solution and problems that the general public, the students, and citizens contribute and learn to solve. CoLAB emerges as a new learning model that aggregate learners across discipline and experience boundaries and collaboratively work on the open wicked problems. It adopts a problem or project-based learning approach as the open wicked problems are so complex and entangled that the traditional instruction based learning is not sufficient. It also highlights collaborative learning and boundary-crossing learning as these open wicked problems, in real world, are no problems to be solved by single person or with single perspective.

As new CoLAB initiatives such as workshops, competitions, hackathons, summer camps etc. are emerging fast in our universities and schools, it is important to understand CoLAB and its process from a practice-based perspective, since the CoLAB itself is a “open wicked problem”: understanding an open wicked problem is essentially not separated from resolving it. The practice-based understanding is our first motivation in this thesis. Also, as more and more practitioners from a variety of background join to participate and organize CoLAB, it is essential to meet their pragmatic need to facilitate these practitioners with easy understandable analytical tools. To meet the pragmatic need is our second main motivation for our thesis.

With these motivations, we adopt the constructivist grounded theory method which allows us to delve into the complexity of the issue, and which is also pragmatic purpose oriented. Through literature review, the CoLAB is framed at the crossroad of collaborative learning and learning across boundaries. Especially, we inherit the socio-cognitive perspective and socio-cultural perspective of constructivist collaborative learning research tradition in our CoLAB study. With the socio-cognitive perspective, we focus on the interaction and micro scenario of the CoLAB process, with an in-depth case study. With the socio-cultural perspective, we rely on a grounded theory of a long-term ethnography observation into a series of CoLAB workshops.

We generate the core concept of “Co-Meaningfulness” in our grounded theory study. Instead of only constructing a joint project while they learn, learners are also explicitly or implicitly constructing a Co-Meaningfulness in CoLAB. The process is especially salient when the learners meet difficulties in communication and collaboration, which is also the situation where the code of “meaningfulness” first emerges. When learners meet difficulties in communication and collaboration in CoLAB, they do not only communicate on the “Project” level, but also need to communicate at the “Meaningfulness” level, to negotiate which parts or components of the Project is more meaningful. The underlying “meaningfulness” is crucial as it drives the direction of each learners’ expectation, and also their interpretation of the project. However, the negotiation is not always explicit or efficient, sometimes learners might not even realize the real problem is the divergence in understanding the “meaningfulness”.

With further analysis of a typical challenging CoLAB case in the socio-cognitive perspective, we conclude that the meaningfulness is project related, important as a collective status and it is developing in the course of CoLAB. We use Co-Meaningfulness to indicate the project-relevant, collective and developing status of the learners’ meaningfulness. Two key properties are generated from the coding and categorizing: the P-M Intensity and the M-M Coherence. The P-M Intensity indicate how intensive the learners engage their meaningfulness into the project, e.g. how well they present the meaningfulness, how effective they communicate the meaningfulness, and how active they motivate themselves in engaging their meaningfulness, etc. The M-M Coherence means how coherent their meaningfulness is to each other, e.g. are their meaningfulness conflicting to each other, fulfilling one meaning sacrifice the other, or are their meaningfulness supporting the other, etc. The two properties are qualitative degrees that can be derived from practitioners’ observation and reflection. To visualize the trajectory of CoLAB, we use the two properties as two axes and build the Co-Meaningfulness quadrant, where the CoLAB process trajectory can be allocated.

We further study the socio-cultural perspective of CoLAB starting by starting to ask what exact “meaningfulness” is. With further grounded theory, we find three key codes in the CoLAB process are especially important in understanding “meaningfulness” in CoLAB. They are the “Evoking”, “Applying” and “Prioritizing” process. The “Evoking” and “Applying” indicates that the current project “Evokes” the learner’s past similar experience and associated social meaning which the learner “Applies” to the current project. The “Prioritizing” means there is not only one past project and one associated meaning to evoke and apply, and the final meaningfulness is the prioritizing the most relevant Project and Meaningfulness, with respect to the learner’s intrinsic priority and the environmental factors of the specific learning

situation. “Evoking”, “Applying” and “Prioritizing” connects “Meaningfulness” to the socio-historical and socio-cultural perspective of the CoLAB. When the learners implement multiple evoking, applying and prioritizing, they construct the Co-Meaningfulness. And the Co-Meaningfulness develops as the learners constantly re-evoke, re-apply and adapt their prioritizing.

The whole Co-Meaningfulness grounded theory answers our initial motivation and questions, especially in understanding the key challenges and process of CoLAB from a practice perspective. It is also a visualize tool for reflecting and analyzing CoLAB that will help practitioners and learners to better practice. In the next sections, we will focus on these key contributions of “Co-Meaningfulness” and the prospect use of Co-Meaningfulness.

2.The Key Contributions of “Co-Meaningfulness”

In INTRODUCTION.4, we explain our primary motivation for this thesis, which is to generate a practice-based understanding for CoLAB and to meet the pragmatic need for CoLAB learner and practitioner. In this section, we would like to conclude the key contributions of “Co-Meaningfulness” and how it is meaningful for our initial motivation.

Co-Meaningfulness for Understanding the Key challenges in CoLAB

The category of “Co-Meaningfulness” is generated when we closely scrutinize the challenges of CoLAB. It explains how and why CoLAB is difficult in its practice and what causes the challenges in the communication, collaboration and learning. Problems seemingly happening at the project level in fact reflect the underlying conflicts in believing what is more meaningful. In CoLAB, everyone proposes their different “Project Components” (e.g. a specific function of the project), which they have to assemble into a coherent project in solving/resolving their target open wicked problem. But since the learners have different background, the meaningfulness behind each project component is often divergent. When communication happens only at the project level, the divergence of meaningfulness often makes CoLAB a challenging process.

Two key CoLAB challenges emerge when we focus on the “meaningfulness” level. The first key challenge is the explicit and implicit conflicts in understanding and assembling the different project components. In the second episode of “Jumping Video”, Xid, as a designer, believes the

“experience of associating user and the camera” is the most meaningful component while Ming, as an engineer, focuses on the specific lighting effect. Their divergent meaningfulness leads to divergent understanding of their project components and eventually the whole project. The second key challenge is the inefficiency in communicating and engaging one’s meaningfulness in the project building. In the third episode of “Jumping Video”, both Ming and Ji try to present many different project components, but not able to efficiently or sufficiently communicate their meaningfulness. Xid can understand their proposition at the Project level, but she cannot fully understand their underlying meaningfulness. Sometimes, learners also compromise their meaningfulness by not engaging them in the project building, which also triggers the second type challenge.

From the comparative analysis of the different challenging learning process, we generate two key properties of “Co-Meaningfulness”, which are the the Project-Meaningfulness Intensity(P-M Intensity) and Meaningfulness-Meaningfulness Coherence (M-M Coherence). P-M Intensity indicates how intensive the “Co-Meaningfulness” and the “Project” mutually influence, especially how well learners are able to present, embed, engage and communicate their meaningfulness. and M-M Coherence indicates how coherent their different individual meaningfulness are - whether they align with each other, support each other, or contrast each other.

When we use the two properties to form the Co-Meaningfulness quadrant map (with P-M Intensity as Y axis, M-M Coherence as X axis), we see clearly the challenges can be located in the different quadrants of the map. The Co-Meaningfulness trajectory can help us visually locate these problems and challenges in the map, as illustrated in the following figure, which presents the trajectory of the “Jumping Video” project, where Episode 1,2,5 have comparatively low P-M Intensity, while Episode 3 and middle of Episode 6 have low M-M Coherence, and Ep.4 encounters both challenges.

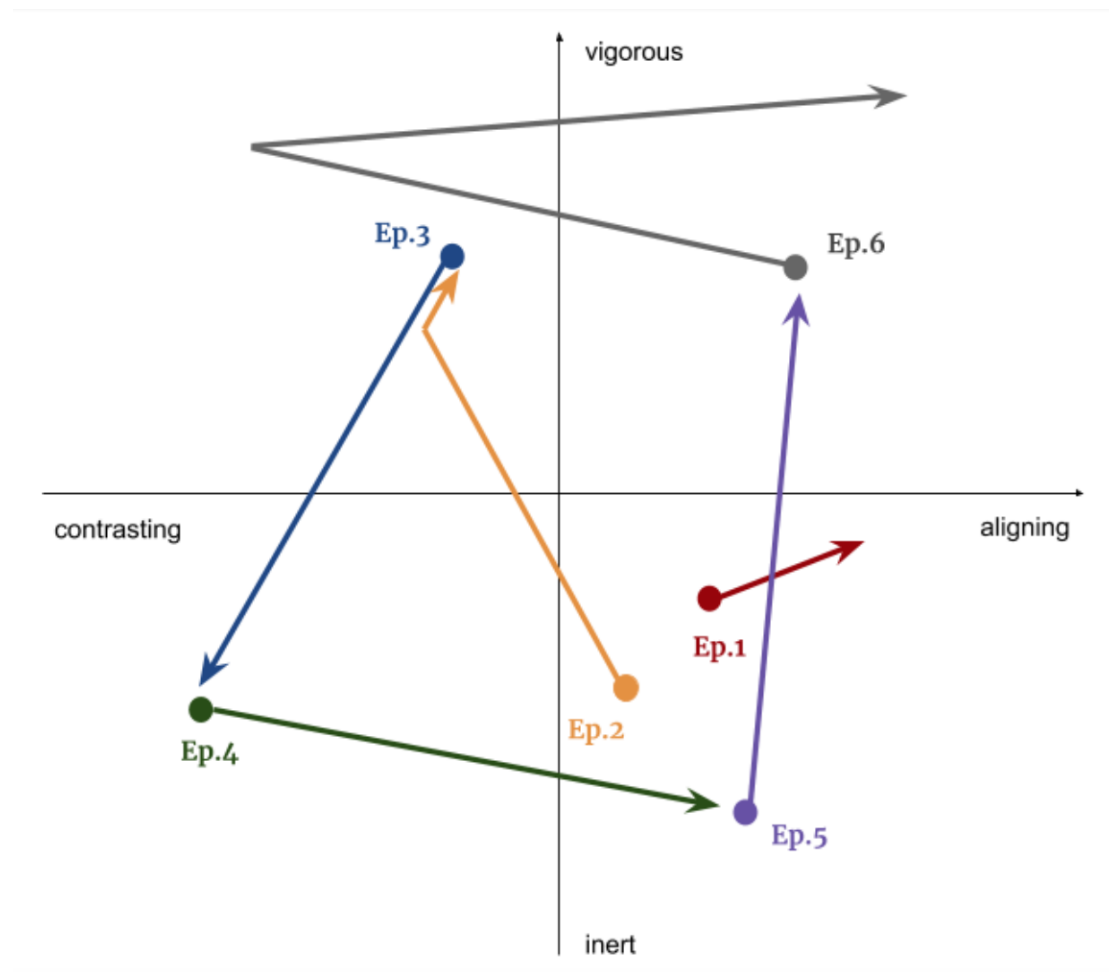


Fig. 13.1. Co-Meaningfulness quadrant map

Understanding the key challenges of CoLAB has two pragmatic uses. First, it helps educators who want to practice or have been practicing CoLAB to understand the socio-cognitive barrier in practice, and more importantly to help them understand it from a deeper perspective: that problems are not just happening at the Project level, but at the meaningfulness level, namely the divergence of meaningfulness and the inefficiency to engage meaningfulness in the project. Designers might not be just arguing on the appearance of the prototype with the engineers, but in fact about a specific meaningfulness that is reflected through the appearance. These kinds of problems are not so obvious so that new CoLAB learners and practitioners might fail to skillfully present or even to realize. But these problems, as they influence the underpinning socio-cognitive process, will cause fundamental challenges in CoLAB, as we have observed and analyzed in last episode of the “Jumping Video” Project.

When these challenges occur, CoLAB practitioners need to understand what they are and why they appear. Using the Co-meaningfulness map can help us categorize and understand these problems, and hence to fix them. if it is the

problem of M-M Coherence, we need to guide them to better understand the divergent meaningfulness that each one holds and help them to merge the meaningfulness through assembling the project or to select the meaningfulness that is relevant and discard irrelevant ones. If it is the problem of P-M Intensity, we need to again guide them to present and engage the different meaningfulness, e.g. by asking them why they propose this specific project component, why it is meaningful or important to the learner, what past project is similar to the project components you propose, and why they were meaningful, and to communicate the meaningfulness, e.g. by trying to ask them if there is a good way to animate or to visualize the meaningful part so that everyone else can understand it.

The second use of Co-Meaningfulness is for practitioners to review and reflect on their CoLAB process by analyzing the good or less productive practices. By drawing the meaningfulness quadrant and trajectory, learners and practitioners can visually reflect the journey and identify the key moments of CoLAB process. For example, in the “Jumping Video”(see Fig. Con.1), the episode 5 sees a rapid growth in both the P-M intensity and M-M coherence. This episode marks a big change of the group’s working dynamic and environment. As suggested by Xid, the group went outside and tested their idea during this period. The testing prototype presented very well both Xid’s Project component idea and her meaningfulness so that Ming and Ren can finally understand the underlying meaning of Xid’s meaningfulness of “experience of associating user and the camera”. All the learners agree that it was a key moment of their project building and they conclude it was crucial to “play” outside and present one’s idea with a work-in-progress prototype. The Co-Meaningfulness map is useful when learners and practitioners reflect their process of learning by studying the key moments and turns of their learning process.

We will however emphasize here that Co-Meaningfulness framework do not intend to give universal guidelines for good practices for CoLAB. During our research, we find that every CoLAB is unique (which is also one feature of wicked problem), and that the different mentors, different topics and different environment all contribute to the uniqueness of each CoLAB, influencing the dynamic of the learning process. Sometimes, the same practice might lead to entirely different process by different learners or under different learning situations. The Co-meaningfulness is a framework of merits to evaluate the different practice but it does not generate a recipe for all. In fact, trying to generate a all-in-one recipe is dangerous, as it may reduce the complexity of the CoLAB practice as an open wicked problem. Co-meaningfulness is useful in promoting profound and holistic understanding of CoLAB process as complex as it is, not a reduced one with parameters to measure and simple solution to follow based on the measurement. We believe the most suitable

solution is only attainable by the practitioner and learner who actually learn and practice on the specific CoLAB and understand in-depth the topic and dynamic of the learning process. We encourage practitioners to reflect deeply with the Co-Meaningfulness framework and analyze on the key moments of Co-Meaningfulness trajectories, which is the most beneficial way of using this concept and framework.

Co-Meaningfulness for Understanding the Developmental

Role of CoLAB

The previous section focuses on the micro process of CoLAB and explains that the key contribution and usefulness of Co-Meaningfulness in the socio-cognitive perspective: that the framework of Co-Meaningfulness (the concept and the associated tools) is useful in understanding the key challenges and practices of CoLAB. In this section, we will explain the contribution of Co-Meaningfulness in the socio-cultural perspective, focusing on the developmental role of CoLAB, and how CoLAB practitioners can develop collaborative and boundary-crossing creativity with the framework of Co-Meaningfulness.

The Co-Meaningfulness in the socio-cultural perspective first focuses on what “meaningfulness” is. From the coding and analyzing, we find out that meaningfulness is related to three process - “Evoking”, “Applying” and “Prioritizing”. The first process of evoking means that the current work-in-progress project “Evokes” an past experience - for example, an engineer might evoke his/her past engineering project with relevant method and tools, then the learner “Applies” the social meaning of that past project to the current work-in-progress project. The “Evoking-Applying” pattern associates the learners’ past experience and related social context to the current work and learning. But these evoked and applied Project/Meaning (P/M) are only a prioritized fraction of his/her larger potential network of the personal experience, and its social meaning. The final “Meaningfulness” is manifested in the prioritized P/M emerging from the larger network of potential P/M. The underlying process of “Prioritizing” is essential in understanding “Meaningfulness”, because it distinguishes the “Meaningfulness” from any “Meaning” that fits, but features the “prioritized” meaning given the learners’ socio-historical experience and the current learning situation. In the meantime, the underlying larger network of potential P/M are temporarily oppressed/neglected.

The “prioritizing” makes CoLAB possible as different learners have to “re-evoked”, “re-apply” and “re-prioritize” to integrate the divergent evoking, applying and prioritizing. When different learners brings in their different “Meaningfulness”, they also brings in their distinct “evoking”, “applying” and “prioritizing”. Therefore, building Co-Meaningfulness is a process where the learners need to incorporate different past P/M as well as their different ways of prioritizing. The situated learning activity will trigger the temporarily oppressed/neglected P/M. If they are fit, they will be re-evoked and re-applied, which will finally lead to re-prioritizing of the oppressed/neglected P/M. For example, in the project of “Chrome-Air Attack”, we observe several process that features the re-organization of “evoking”, “applying” and “prioritizing”. The most influential reorganization happens when Denqing presents the scenario of the colorful bouncing balls and proposes to attach a bio-sensor to a colorful bubble. The very beautiful scenario triggers what the learners later describe as “the romantic feeling”, which eventually evokes the science fiction idea and applies the associated meaning of “speculating a plausible feature with a romantic and ironic bio-tech artifact.” This final P/M was initially oppressed/neglected, but, as we have seen in the final result, they do have the potential to be re-evoked, re-applied and finally re-prioritized. In the post-interview, the learners also prioritize the meaning of “romantic” which was not a priority before.

The developmental role of CoLAB exists in the reorganization of evoking, applying and prioritizing. To understand the developmental view of CoLAB, we need to ask what exactly learners learn from CoLAB. There are three levels of learning objective of CoLAB. First: we learn through making project oriented to solving/resolving an open wicked problem, and that project, as one potential solution for the open wicked problem, is one of the learning objective. Second: we learn the necessary knowledge and skills useful in the Project making, from all sorts of learning materials, and from our mentors and peer learners, through making the project. Third: we learn from building Co-Meaningfulness, which includes the practice of overcoming the challenges of meaningfulness divergence and lack of meaningfulness communication, and the practice of reorganizing the “evoking”, “applying” and “prioritizing”. As a result of the third level of learning, both the new project and its social meaning has entered the learners “potential network of P/M”, and at the same time, the process of building Co-Meaningfulness also expand the learners’ original way of prioritizing. The learners expand their original network of P/M with the new Project and Co-Meaningfulness, their original prioritizing with the new prioritizing brought by the new Co-Meaningfulness. This expansion is otherwise difficult through vertical learning, which reinforces rather than expand the original P/M network and prioritizing.

The expansion of boundary-crossing P/M and more adaptability and comprehensiveness in prioritizing marks the development for the learner. The ultimate purpose of CoLAB is to develop learner to be more capable in solving/resolving the open wicked problems, as CoLAB aims to promote boundary-crossing innovation and creativity to solve these problems. The developmental role of CoLAB serves this purpose. Our individual experience is limited, so is our with-in boundary experience in vertical learning. CoLAB helps us break the boundary and make possible the connection between the open wicked problem and our own experience in new ways - by introducing new Project and Meaning and by reorganizing our way of prioritizing. From the socio-cultural perspective of Co-Meaningfulness, the collaborative and boundary-crossing creativity is obtained through constantly developing our experience, its associated meaning and by improving our prioritizing versatility of the P/M network.

To practice CoLAB is not one-time work, it has to be a consistent and sustained practice. The Co-Meaningfulness framework, especially its socio-cultural perspective helps learner and practitioners to understand that each time CoLAB is done, the Project and Co-Meaningfulness is part of the development, as they enter the P/M network of the learners, developing the versatility of their prioritizing. The next time in CoLAB, learners are equipped with more entangled network of experience and meaning as well as more adaptable and comprehensive ways of prioritizing from which they build the next Co-Meaningfulness - and possibly lead the development of novice CoLAB learners through this new Co-Meaningfulness. The development within the learner and between learners can be a chain reaction when learners and practitioners understand the developmental role of Co-Meaningfulness in CoLAB.

3.Prospect of Using “Co-Meaningfulness”

Before we discuss the prospect of using “Co-Meaningfulness”, we remind that the “Co-Meaningfulness”, at the end of the thesis, indicates two aspects: 1. “Co-Meaningfulness” is the key concept of our grounded theory, which is often used to stand for the grounded theory. In this sense, the “Co-Meaningfulness” is associated with its properties, tools, and collectively, a framework. 2. “Co-Meaningfulness” as a standalone concept also indicate the substantial “collective meaningfulness” generated and emerged from the CoLAB learning. Both the framework and the substantial aspects have the prospect of use in the following discussion.

Using Co-Meaningfulness Grounded Theory as a Conceptual and Reflective Tool

The first prospect of using Co-Meaningfulness has been proposed in the previous section. Co-Meaningfulness is a conceptual and reflective tool. We first recommend the future use of Co-Meaningfulness to identify and understand the key problems in the CoLAB, which is often difficult for novice learners and practitioners. Using “Co-Meaningfulness” in this sense does not mean to present the complete theory to the learners when they meet difficulties, which we suspect will only cause confusion. It means practitioners need to consider the conflicts and inefficiencies at the “Co-Meaningfulness” level, when difficulties appear, and give guidance accordingly. The Co-Meaningfulness as a reflective tool helps practitioners/researchers to review the trajectory of the learning process. Using the reflective tool will require the practitioners/researchers to record or keep notes during learning.

Using Co-Meaningfulness as the Chain Reaction Catalysis for CoLAB.

The second prospect of using Co-Meaningfulness has also been briefly mentioned in the previous section, when we explain how Co-Meaningfulness casts light to the developmental role of CoLAB, as we say:

“The Co-Meaningfulness framework, especially its socio-cultural perspective helps learner and practitioners to understand that each time CoLAB is done, the Project and Co-Meaningfulness is part of the development, as they enters the P/M network of the learners, developing the versatility of their prioritizing. The next time in CoLAB, learners are equipped with more entangled network of experience and meaning as well as more flexible and adaptable ways of prioritizing from which they build the next Co-Meaningfulness - and possibly lead the development of novice CoLAB learners through this new Co-Meaningfulness. The development within the learner and between learners can be a chain reaction when learners and practitioners understand the developmental role of Co-Meaningfulness in CoLAB.”

In the discussion here, we will focus on how to use “Co-Meaningfulness” (as a substantial “Collective Meaningfulness” generated in CoLAB) as a chain reaction catalysis for CoLAB. Experienced CoLAB practitioners such as Denqing and Juanmat often use the “Co-Meaningfulness” built in a CoLAB to

catalyze the next CoLAB. For example, the bouncing ball video (see Appendix C.4 Denqing's bubble) is often mentioned by Denqing when he wants to explain the meaningfulness of designing for a large scale of interaction. In the series workshop "Colab bio-design", the Co-Meaningfulness in the Project "eatable book" integrated the meaningfulness of innovation in material science, playfulness, educational and communicational purpose, and was highlighted in multiple versions of the workshops as prompts and even special practicum sessions. The "Co-Meaningfulness" in these Projects are naturally catalyzers because they have successfully resulted in re-evoking, re-applying and re-prioritizing in a CoLAB, which proves their complex and adaptable connections to the open wicked problems. They serve as a hub of the P/M network, not only in one individual, but also in a boundary-crossing group. Their role is similar to the "boundary object" for learners across different background, which bears the boundary-crossing potential.

To use good "Co-Meaningfulness" as catalyzers, we want to remind three things: First, Co-Meaningfulness is not separated from the "Project". Since the very beginning we give the name "Co-Meaningfulness", it has remained closely related to the "Project". For using "Co-Meaningfulness" as a catalyzer, it is not much helpful to just talk about meaningfulness without presenting the project. When Denqing presents the bouncing ball example, the visual and animation is a big part in understanding the meaningfulness. The "Project" helps to better present the "Meaningfulness", as well as to present how "Meaningfulness" is associated to a real "Project", and finally the "Project" can facilitate novice learners in (re-)evoking and (re-)applying.

Second, it is also not useful to just talk about the "Project" without mentioning the associated "Meaningfulness". It is often troublesome when learners and practitioners just present the "Project" hoping meaningfulness will naturally follow. In CoLAB, this is not what actually happens, as we have observed and studied in many situations in this thesis. When the CoLAB practitioners want to use "Co-Meaningfulness" as catalyzers, they should take their time and explain deeper on the "why" questions: why do I want to present the project here? Why is it important for us and the problems? The catalyzing power will be best stimulated when "Project" and "Meaningfulness" combine in the Co-Meaningfulness.

Third, practitioners should understand that each CoLAB is unique, thus the best way to use "Co-Meaningfulness" as catalyzers is through evoking and adaptive prioritizing – meaning that the "Co-Meaningfulness" is not prepared as a reference, but timely evoked in response to the current learning and working project. In this way, the catalyzer "Co-Meaningfulness" carries both its original meaning and its new connection to a different topic and a different community of learners, through the experienced practitioners' evoking,

applying and adaptive prioritizing. This ultimate chain reaction also implies that the catalyzing power does not only exist in the “Co-Meaningfulness” as an “substance” but also is manifested in the learner and practitioners’ adaption and using. The catalyzing and scaling of CoLAB is never isolated from the specific learner and the situation, which is ultimately because of the openness and wickedness of CoLAB as an open wicked problem.

Developing the Co-Meaningfulness Grounded Theory

The Grounded Theory of Co-Meaningfulness is not ended here. Its structure and content is highly related to our initial motivation and questions, due to our personal interests with personal reasons. In a constructivist perspective, this personal standing point is important in understanding and constructing social reality, which is adaptable to other’s use and development as the construction is in its essence socially coordinated.

If seen from a Co-Meaningfulness perspective, our grounded theory also constructs a Co-Meaningfulness that everyone can evoke and apply with their own experience, knowledge and meaningfulness, and everyone can develop it with their own interests. If the learners/practitioners/researchers hold a constructivist perspective as we do, they can follow the research steps we present in the thesis and develop the framework. As we understand most of the learners and practitioners might not know the method we use, we deliberately present the data, method and analysis in detail (see original coding and categorizing in the analysis and Appendix).

For example, one might be interested in CoLAB creativity specifically in the socio-cognitive perspective. He or she might use the CoLAB trajectory to locate the key turning moments which he finds important to construct the understanding for socio-cognitive creativity. Then the researcher might add more coding and categorizing with their interested topic to the P-M Intensity and M-M Coherence coordinates. The framework of “Co-Meaningfulness” has a focus on the process which might inspire practitioners who work on the frontline in building their own understanding of their distinguishable CoLAB process. We keep an open attitude and welcome any further development of the grounded theory.

Extension to the Objectivist and Big-data Based Study

What happens when a practitioner is going to organize a CoLAB with 500 participants, or even more? How do they understand the different process? How is “Co-Meaningfulness” going to be useful in this case?

This is a question that CoLAB practitioners will face, especially when CoLAB is becoming more and more popular. Although our intension in this thesis is to present a zoom-in perspective, I constantly meet with situations where I have to host CoLAB in a large number scale. These opportunities are exciting, but also create a great challenge for understanding and evaluating the process. How are we going to analyzing the so many different process, and generate useful knowledge of CoLAB in this situation? How can we integrate these understanding without losing the complexity of the issue?

One proposal is to extend the “Co-Meaningfulness” framework to the objectivist and big-data based study. The “Co-Meaningfulness” grounded theory is built with the “practice sensibility”, which means the researcher himself is the research tool to understand and analyze based on his considerable experience in CoLAB practice. The benefit is apparent – the research focuses on the most important questions of practitioners and understand them with a “frontline” insight and a zoom-in intension, but the shortcoming is also obvious, that it is hard to scale to a large number of situations across time and space. However, an objectivist researcher might lose the “practice sensibility” while he or she alienates himself/herself to the practice as an neutral observer. Hence it is helpful to develop a mixed perspective which derives objectivist observations from the Co-Meaningfulness framework.

Co-Meaningfulness is a concept associated with qualitative observation and coding in the constructivist perspective, but it is also presented with properties that have the potential to be quantified. One might need to set up a protocol for observation, and use objectivist tools such as surveys and scales to ensure minimum bias in the study. When sufficient objectivist measurement are made, the P-M Intensity and M-M Coherence can be used in a large scale to evaluate the process, which also inherits its practice sensibility as it presents to some degree the important qualitative changes in the process. When the data is large and in high dimension, we can also extend the framework into an analysis based on artificial intelligence, e.g. a supervised learning to distinguish different trajectory type based on features extract from behaviors that will influence the P-M Intensity and M-M Coherence. There are however challenges when researchers want to analyze further with evoking, applying and prioritizing as these processes will require understanding from a socio-cultural perspective, which is inherently related to the learners learning history and cultural context. A more ambitious longitude comparative study might help us in understanding these perspectives.

To conclude, the first two prospects of using “Co-Meaningfulness” align with our previous explanation of “key usefulness and contributions of Co-

Meaningfulness". We believe the benefits we bring to our practitioners and learners in learning, facilitating, and developing in CoLAB are the most essential prospects of our thesis. In addition, we also discuss the potential use of Co-Meaningfulness as a grounded theory for researchers/practitioners with either constructivist perspective or the need to mine from big-data: this thesis tries to meet the pragmatic need of CoLAB learners, whoever they are, and whatever presumptions they hold. Because we know that many more people with divergent background will join in the CoLAB adventure and our thesis is a proposal not to exclude anyone just because they have a different perspective, but focus on how to help and inspire as many CoLAB learners/practitioners/researchers as possible.

APPENDIX

A. Project of “Jumping Video”	242
A1. Conversation and Coding	242
A2. Interview and Coding	270
A3. Memo and Coding	281
B. Project of “DNAish Food”	298
B1. Chris’s background	298
B2 Matt’s motivation	301
B3 What’s interdisciplinarity	304
B4 Lina’s design examples	308
B5 Does Science Communication Need Emotion	310
B6 Labelling DNA content	312
C. Project of “Chrom-air attack”	316
C1 Interaction Design – Reinventing the Rules	316
C2. The Metaphor of Weapon	321
C3. The start of the idea	327
C4. Denqing’s Bubble	329
C5. Scientific and Romantic	332
C6. The science fiction	334
D. Co-Meaningfulness Trajectory Examples	336
D1. Co-Meaningfulness Trajectory Example of B2	336
D2. Co-Meaningfulness Trajectory Example of B3	337
D3. Co-Meaningfulness Trajectory Example of B5	338
D4. Co-Meaningfulness Trajectory Example of B6	340
D5. Co-Meaningfulness Trajectory Example of C3-6	341

A. Project of “Jumping Video”

A1. Conversation and Coding

No.	Transcription	Initial Coding
1	2016.12.13 in classroom, before blackboard (Xid,R&M)	
2	Ming: So its relative position in space is like this.	Proposing project
3	Ren: No matter how big (the light is), it will be included in the picture	Exposing project problem
4	Ming: maybe a little.	Admit problem with hesitation
5	Ren: look, let's open camera application of phone, it's a wide fov. The light would surely be included in the photo	Elaborating on the problem
6	Ming: yep... but maybe, we made it a square, like a frame, it would be interesting. Square or circle.	Proposing function- frame; Believe frame “interesting”
7	Ren: how about this, the circle is here (draw on the blackboard) selfie stick is here, or the circle is down here. And we can adjust the angle.	Proposing alternative solution with adjusting angle
8	Xid: For me, I think if the light have to be in the photo, it's better to make it look like a frame	Choosing one solution
9	Ming: yes frame is artistic.	Feeling “artistic”
10	Xid: haven't you heard of ... some tourists took selfie and it's ... (can't hear)	Raising new scenario
11	Ren: outside is necessary to fill light? Because the outside the light is already bright	Questioning scenario with old function
12	Ming: not just for light itself, but for different effect. Light from different angle would have different emotions.	Proposing new function and effect. Introducing “emotion”
13	Xid: if it is a frame, we could put LED in different colors.	Introducing effect of “different Color”;
14		
15	Ren: in the middle, you can fix like this. It can rotate like this.	Solving technique problem ; propose function “rotate”
16	Ming: it doesn't need to rotate.	Rejecting function
17	Ming: like the television.	Supporting rejection
18	Ren: so we agree to do this?	Asking for agreement

19	Ming: yes	Confirming
20	Ren: but how OK	Self repaired Questioning;
21	Ming: we can test many modes with this. E.g. filter like light etc.	Proposing divergent function of modes.
22	Xid: I think foldable .. we need to know the technical detail	Checking feasibility of “foldable”
23	Ming: reflection board it's foldable	Proposing material for foldable
24	Ren: we could find some place to make articulate and make it foldable, like this.	Proposing mechanics for foldable
25	Ming: ah yes, in this way it's foldable.	agreeing
26	Ming: for the first version, we could use wood, and next, we can use better material/	Proposing material
27	Xid: or paper.	Proposing material
28	Ming: but it's too weak.	Unfeasible – too weak
29	2016.12.14 in the cafe (X&M)	
30	Xid: Can you go back to the idea of selfie and light, but not focus on the selfie stick peripheral ? I think it's complicated to hack the stick, and we are not going to really hack it when we present. And we don't have a stick	Demanding a rewinding of idea; explaining rationale : too complicated; no material at hand
31	Ming: I just bought it.	Disagreeing on part of the rationale
32	Xid: I mean, we can return to the point of light effect.	Emphasizing on main demand
33	Li: how we can relate to movement	asking how to relate to workshop requirement
34	Ming: last time, when I took a photo of my classmate, and my hand shakes a bit , the effect was very good.	Recalling past experience to support a good effect – shaking photo
35	Xid: you know, what I am thinking is, let it shoot automatically, and you make crazy movements, dance, whatever, and then the it can fill light accordingly, same crazy.	Proposing new project idea; describing on the effect – crazy movement and light associated
36	Ming: OK	indicating understanding
37	Xid: Or maybe, I can wear the device and dance, and certain movement would trigger the shooting. And the light might adapt to the music.	Keep proposing new function and effect – dance and shooting trigger.
38	Xid: let's think about this scenario: in a dark photography studio, there's some colorful line light, some people are dancing. Maybe some movements would trigger the shooting, and then we can have very natural photo.	Proposing scenario – dark studio with colorful light. Proposing effect and purpose – natural photo:

39	Xid: just now, we were thinking about one person, but we could have multiple people interacting in it. I am just proposing this idea, you can also change it.	Proposing scenario and interaction – multiple people; inviting for advice
40	Ming: the trigger ?	Indicating confusion
41	Xid: just the shutter	Brief explaining
42	Ming: We haven't reached how we place these lights on the floor.	Asking question on technical detail – how to place light
43	Xid: We could describe the scenario as a dark room, we could also find a such place.	Answering by give a scenario
44	Ming: no. I mean how you can place and fill the light.	Refusing answer; repeating question.
45	Xid: it's the realistic part, but we are now doing a prototype, we don't need to go that far right ?	Rejecting the need to further discussion on the realistic part; providing rationale: prototype
46	Ming: But even for a prototype, you need to think about these in order to present/express the idea.	Rejecting rationale; arguing on the prototype's presentation
47	Xid: what do you mean ?	expressing confusion
48	Ming: meaning that if you want to present the idea, you need to, for example, the light projected on the dancer can have certain effect. Dancer... the certain movement. ...	Emphasizing on the detailed effect as part of the prototype
49	Xid: the prototype is mainly for describing the basic function and then a good video or picture to showcase.	Rejecting the understanding of prototype; providing an alternative understanding of prototype
50	Ming: but if the function includes the light, then we must decide where the light came from and where it projects to.	Insisting on the specific setting
51	Xid: this should be included in the written description. We don't need to include it in the prototype.	Excluding the detailed setting from prototype
52	Ming: But the prototype is after the written description right. Prototype is for demonstrating the idea, which include the light.	Rejecting, insisting on including the setting.
53	Xid: i think B light (?) should work. We can buy a curtain, and then we can take the picture.	Proposing a specific setting
54	Ming: yes, we could think twice on the detail.	Agreeing on more thinking
55	Xid: you think it will work ?	Asking for agreement
56	Ming: yes. I am now thinking maybe we can just use top light .	Agreeing; proposing new setting and effect – top light

57	Xid: can be multiple light, we might also refer to the MF room. But that is very professional. We are for fun. How people can really play with it. I think a design should first touch people.	Proposing new effect – multiple light; exhibiting implicit purpose: having fun , touch people ;
58	Ming: yes, this point is very important. And this actually contribute to my points. Because you say it would be fun, but you omit all the details, it's very abstract now. One beam of light is not such fun.	Accepting the meaningfulness of fun; opposing neglect of specific effect is fun; abstract not fun
59	Xid: I meant to have colorful light as new function. It can change according to music ... it might be fun.... Can it rotate? No, right? Actually I was thinking about spot light. That might be fancy. But now we have only point light. In worse case, we post-process.	Proposing new effect and function: colorful , spot light. Proposing
60	Ming: we need to have a demo live right ?	Inquiring on presentation format
61	Li: What the idea now?	Asking for progress.
62	Xid: because the selfie is not ideal, I proposed another idea. No selfie stick It's just light and movement, and we interaction with it. We simplify it to light and music as background, light go with music we can control the color and brightness. the dance is the trigger, so the picture we took is quite free. And then we can have Multi users.	Explaining new direction.
63	Li: how relate to movement.	Inquiring on relation to workshop topic
64	Xid: the movement will trigger the camera.	Explaining the function
65	Li: Where is the camera?	Asking for detailed setting
66	Xid: I am thinking of a dark room, the light is in front of me, and the camera behind the lights.	Explaining scenario and setting
67	Ming: we think it's kind of interesting interaction. But we need more detail in the space design.	Agreeing on the interaction; feeling interesting; requiring more detail
68	Li: I think it's too complicated. I don't understand the need. Why there is a camera ?	Rejecting the idea – too complicated. Express confusion: use of camera
69	Xid: the scenario could be in a bar. When we are having fun. Or some scenario	Proposing scenario; and interaction;
70	Li: it remind me some people put camera in the wild and the animal would trigger it. But I don't know with human..	Giving related examples. Questioning adaption.
71	Xid: for example when we are in the roller-skater, someone took picture of us on the top. It's the same idea. The movement can trigger the most exciting movement.	Answering confusion and Justifying with new scenario and purpose

72	Li: but the relation to movements..	Questioning link to the workshop topic
73	Xid: is the trigger... might be a little unconvincing	Expressing no confidence.
74	Li: and why this movement would link to photo-shooting is unclear, where is sensor., looks like it's becoming more complicated. Rather have someone take the picture for you.	Questioning the practical rationale of the design. Feeling complicated; resembling plain scenario.
75	Xid: but having someone there taking the picture is fun-killing. You will feel not as free.	Justifying with previous meaningfulness "fun"
76	Li: and to fix the camera you need to have a tripod. It's troublesome.	Rejecting, technical detail complicated,
77	X; you can fix it to the wall.	Proposing solution
78	Ming: or somewhere far.	Supporting by proposing solution
79	X; but we are thinking about some space small.	Questioning scenario
80	Ming: for for dance, it wouldn't be so small. I think you (Xid) are pretty near, but need more details of the space. How we put the light, the angle of the camera, in more detail.	Encouraging peer – pretty near, pointing out weakness
81	Xid: can be in a dancing club.	Proposing a scenario
82	Ming: you can draw it, 3d drawing. Otherwise it would be very abstract for us.	Inviting visualization for clarifying
83	Xid: but I don't have concrete ideas also. It's just an abstract proposal.	Avoiding drawing, no concrete ideas.
84	Li: still thinking it's complicated.	Rejecting idea - complicated
85	Ming: if you can draw it, it is a prototype. A idea-proof.	Encouraging visualization
86	Xid: I don't think so ... sad (kidding)... erhh... how can we draw it? Here is the wall? Curtain, camera here?	Expressing upset. Feeling confused in drawing
87	Ming: the curtain is up there?	Helping to draw details
88	Xid: no on the wall.	Specifying details
89	Ming: where are people? What are their position. ?	Helping to draw details
90	Xid: here	Specifying details
91	M; so you want to design a small room ?	Helping to draw details
92	Xid: but	Hesitation
93	Ming: how many cameras?	Helping to draw details
94	Xid: depend on specific scenarios, i want the light this way.	Proposing the specific detail
95	Ming: so the curtain is a big area, what 's function of curtain ?	Questioning on function
96	Xid: to fix....	Unfinished explaining

97	Li: i think it's not time for all this details. For recording this, I don't think there is a lot of need of this.	Rejecting too much retail. Useless
98	Xid: The goal is sometimes when we take pictures, we make poses that are not very natural.	Explaining purpose: making natural pictures
99	Ming: But we might get a lot of black pictures.	Rejecting due to feasibility problem
100	Xid: there will be black, but also good photos. A photographer always has his own perspective. But this camera not.	Rejecting rejection.
101	Li: why to take pictures in a room ?	Questioning scenario
102	Xid: Because you will not know when you will be photographed. But we define a movement for doing that. we need to find a movement typical or big enough. The trick is you don't know your pose when the camera is triggered, don't you want to try?	Elaborating purpose: unnoticed shoot; implying the fun by inviting playing
103	Li: i kinda understand. But inside a room, to take a picture of movement is not good quality.	Partially accepting. Questioning on quality
104	Xid: depend on the camera. Even the quality is bad, it doesn't matter.	Rejecting the quality merit. implying different merit.
105	Li: it looks complicated. Some one can take the job	Rejecting – feeling complicated; replaceable to human
106	Xid: But with or without is a photographer is definitely different. We will act when facing someone.	Arguing for new rationale : avoid acting
107	Ming: Many professional photographer, one of their job is to take your picture without your awareness.	Supporting new rationale
108	X; try to capture your distinct movement, moment that you yourself might not even notice. It might surprise you , wow , I was like this. Or it might also capture your bad moves. But you will be surprised. It is an experience.	Explaining experience as main purpose.
109	Li: can we connect it in a smarter way ? looks complicated to me	Repeatedly rejecting with single rationale – complicated.
110	Xid: this is my point, you can try to add more in it. Because the stick idea is very hard to continue. To design the movement for controlling the camera. So I am making a counterproposal. What do you think, XM? you want to relate to light right ?	Inviting participating ; asking for confirmation on key function
111	Ming: not necessary .	abandoning function
112	Xid: No? you were so sure. Actually, if light is not necessary, we can leave it out. The essence is to take a picture without your awareness. There is no need to associate the light with music.	Agreeing on abandoning function; changing function

113	Li: Your camera would need tripod right?	Asking about detail setting
114	Xid: can be smartphone. We can hide a smartphone there.	Proposing solution
115	Li: but smartphone can't take good moving picture.	Questioning function
116	Xid: iphone 6s. XM, you remember LIN took a picture of you, and you were moving like this. The picture looks so great. Very funny.	Referring to past fun experience
117	Xid: So if we use the inspiration, we just need to set several movement to trigger the camera.	Using Inspiration
118	Li: or you can control by sound ? because I think it's better to take a static picture. I fear the moving pictures are too bizarre. And people would not like it.	Proposing function – control by sound. Hating bizarre
119	Xid: If all the pictures taken this way are bizarre, then people wouldn't be bothered. The goal is different (than taking good quality).	Embracing bizarre. Implicating divergent meaningfulness
120	Ming: What if we don't need the light at all .	Proposing abandoning function
121	Li: Renjun has some good ideas.	Proposing changing project
122	Xid: I've seen similar ideas, so I am not very motivated. XM you can propose your ideas.	Rejecting – not motivated. Inviting other ideas.
123	Ming: I think about sunflower, so that the selfie stick can follow the face. Like Renjun proposed before..	Proposing new project
124	Ming: Recently I saw company making cradle head that can prevent shaking of the camera.	Relating to recent reading
125	Ming: Can we think of making cradle head worsening the shake?	Proposing abnormal effect
126	Xid: How to make a camera to take shaky pictures. It's kinda different.	Accepting effect, acknowledging being different
127	Ming: let's work on the shake then.	Inviting work
128	Xid: shake ? so we make a camera that looks shaky.. No .. a camera that take pictures while shaking ?	Propose function
129	Ming: yes, or like before, there are some apps turning clear pictures into vintage, glitchy or random effect.	Agreeing, Propose alternative effect and function.
130	Xid: like a camera ... called ... but the shaking effect, I never tried. I think we can try. It's like a opposite design. Normally we prevent the shaking, and now you want the opposite. But how you want to connect to movement ?	Accepting the opposite design. Asking how to relate to workshop topic
131	Ming: for example, it can shake when you legs are shaking.	Proposing scenario

132	Xid: So it means... but how the camera shake ? Or it sways? How it shake with you?	Asking about function and feasibility
133	Ming: so difficult	Expressing difficulty
134	Xid: So you move, and the camera can sense and follow your move ?	Asking about function
135	Ming: yep.	
136	Xid: I think it's a good idea.	Agreeing on project idea
137	Ming: but we won't need a movuino then. We just need a selfie stick.	Reducing reliance on technology
138	Xid: you don't need a selfie stick, you can just sway with your hand.	Reducing function
139	Li: sway and take a picture or after the sway you take the picture?	Raising question
140	Xid: we can try. Let's try.	Proposing prototyping
141	trying ...	
142	Li: oh bad, it's the video mode.	Making mistake
143	Xid: look ! this effect. .. it's cool... So we can do this with hand. We need to think of a new idea.	Liking effect, self reject due to no technology element
144	Xid: look, this is the off-focus effect.	
145	Ming: to combine the camera with the movement of a vehicle.	Propose new project idea
146	Xid: but it's similar to the example.	Rejecting repeated idea
147	2016.12.14 in the cafe (X&M) Part 2	
148	(L came and ask them to explain, Li is an outsider)	
149	Ke: any progress?	
150	 Xid Showing the picture	
151	Ming: we think about the idea : to have an opposite design: many camera wants to reduce the shaking, we can have a camera that increase the shaking. And then we think we can just use hand for this results.	Explaining project Emphasizing the special effect – opposite design
152	Ke: I think this direction is worth digging. Just we need to make the interaction more .. powerful.. I know one interesting camera, when you press the shutter, something like a mouse trap will hit your hand pressing the shutter. And it looks as if it takes a picture in the front of you, but in fact, it takes your picture, your twisted face because of the hurt. The camera will produce a series of pictures of hurting faces.	Encouraging deeper investigation; using metaphor : powerful Giving example Unusual effect – hurting face
153	Xid: (stating her idea of curtain and dark room)	Explaining project

154	Ke: Why I mention the mouse trap camera is because of the unstable camera you mention. You can imagine in the moment of taking the picture, what interaction can happen, so that the shaking can have a meaning, so that from this camera, you will have a series of pictures with the same style. In the mouse trap case, the style is .. we can't say fun... but like black humor. It's meaningful.	Relating project idea to argument associate meaning to shaking Collection of style Explain meaningfulness in black humor
155	Li: like we can surprise someone and take the pictures.	Rephrasing to validate
156	Ke: We don't need to limit to literally do something to human. The point is to capture the moment.	Opening examples to more directions
157	Xid: yes, the previous idea was to capture movement when dancing to music	Relating to own project
158	Ke: you can think what kind of movement is powerful.	Adhering to "powerful"
159	Li: there is one need, some people would like to take the picture when jumping. We can detect and then take picture when they are at their highest point.	Relating to other scenario Practical use
160	Ming: Also when we take jumping pictures together, we are not synchronized. We can calculate the moment when taking the picture	Relating to another problem in the same scenario
161	Ke: you know there is a camera, it's actually a ball, with a fish-eye. You can throw it in the air, and it can take a panorama at the top.	Relating to examples with technology
162	Xid: look this is just now, my two friends takes the capture picture.	Friends prototyping
163	Ke: if we leave out the light. We can follow the camera drama workshop. The title means the camera itself is a drama.	directing to refer to examples
164	Xid: if you fix the camera to the bicycle, you would get a very rotating video.	Proposing new scenario and effect.
165	Ming: Like astronauts training.	Making metaphor
166	Xid: so we need a conclusion.	Urging to conclude
167	Ming: we had already a lot of change of ideas now, before camera shake, light. Tonight, we focus on movement and camera.	Concluding previous work
168	Xid: let me state again what I believe is meaningful in my proposal. First is, the randomness. You don't know when the camera will take the picture. Second the moment you record is very natural. Sometimes when we take picture, it all looks the same as if they can have only one expression on their face. You can change the form but express the same feeling.	Clarify meaningfulness Highlighting random as meaningful Natural picture meaningful Dislike same expression

169	Ming: Or we don't let the movement control the camera, we can let the movement control the light.	Emphasizing Light control
170	Ke: I think we had enough talk. I like the idea. One thing I want to add here is special moments have special meaning. The interaction itself should have meaning. Her idea is the trigger itself is movement. Photography itself can connect to movement. Can be the angle, can be the shutter speed, can be settings , can be blurred at some moment. Some movements can be defined by the camera to be wide FOV, some movements defined to be like from an animals' eyes. There is a lot to play here, but not talk . You need to play with the movements. Like the can't touch example, we designed all the movement, for a whole day. There's a lot of space to play it. I think the idea is good, worth playing and testing.	Approving the project idea Associating moment to meaning Mentioning more parameter Encouraging "playing" Recalling "example" Emphasizing testing
171	2016.12.15 in the classroom (R, Ming Xid & K)	
172	(Ke push Xid to understand XMing's idea on implementation)	
173	Xid: Look, here is XMing's idea, he said we are going to use movuino for movement detection. And then Matt for recognition.	Explaining working progress and plan
174	Ming: and then we use the web to control camera, or with Arduino.	Adding technical details
175	Ke: so do you understand it ?	Asking degree of understanding
176	Xid: I pretend to understand.	Pretending
177	Ke: but in fact no?	
178	Xid: In fact I am not clear how to implement	not knowing detail
179	Ke: you didn't understand how he want to implement, but he is already clear?	confusing
180	Xid: I don't know how he can implement it with the hardware, I understood his general idea. So all of this is meant for triggering the camera	Clarifying confusion
181	Ming: we use the web to control the camera. Yesterday we talked about setting up a fancy environment with curtain and light. And there's a camera, some action will trigger the camera. So here we let people wear the device before dancing.	Completing working plan
182	Xid: so what I explain a lot, but he understood very directly . That it is a movement that triggers the camera. Fair enough.	Expressing frustration Understanding superficially

183	Ke: let's first look at the implementation side. You know how we use Matt to control the web?	Asking technical detail
184	Ming: no.	Not knowing
185	Ke: I don't know either. I only know Matt can control the serial. I think it's a bit complicated.	Not knowing either
186	Xid: he said there's another way, to use Matt for controlling Arduino and then the phone through Bluetooth. I can't really imagine how he will implement.	Not knowing detail
187	Ke: In fact, these steps are trivial . It's limited because we only have this Matt application, but actually what we need is just a smartphone application. We can assume we have this application. I don't think you can finish the Bluetooth within one day, not to mention you have other tasks. Actually here the implementation challenge is not the design issue here.	Defining detail as trivial Lacking support Time limit Having heavy test
188	Ming: So Xid explained to me, and she said this design should be fun.	"fun" as meaningful
189	Ke: hmm. The interaction itself. Think of the "collider" that we did, we can't open the door with machine, so we pull it with our hands. It's all fake but the the Ars Electronica jury liked it. We can imagine we had the technologies.	Referring to example prototyping with "faking"
190	Ming: So, let's have someone control the camera for us, it captures the picture every time the subject made some movements, and then we present the idea.	Borrowing strategies from example
191	Xid: I think it is OK to think about practical application, if he(XM) insist.	Allowing different perspective
192	Ming: I think it is not very necessary to think about its objective, be it practical application or having fun. Because we express the idea through the same implementation.	Reducing deep meaning Implementation is the same
193	Xid: I want to say it's good that smartphone can have this function. Because sometimes when I dance I don't have anyone taking photos for me.	Like one application
194	Xid: so where is our point ?	Clueless on the general idea
195	Ke: I think first the camera itself can be free from just one angle. There is a lot of parameter to adjust, e.g. apture,	Opening to more parameter
196	Xid: ah yes, he totally omit this part, I almost forgot.	Forgetting previous proposition
197	Ming: apture?	Not sure
198	Xid: yes, it can influence many factors, the movement can influence many factors of the camera.	Confirming

199	Ke: you were not there yesterday. (to R) yesterday Xid and Ming had a lot of discussion on the core of the interaction. The very key idea is, before movement was not organically involved in the design. Use movement to control the stick doesn't look that natural. Why use a movement to control the brightness, the association is not obvious or natural, we can just use a button. So the question now is that the movement itself should be involve, not as a redutant element, but a necessity. So yesterday, one result is whether the movement can be a trigger, at the same time,	Explaining previous discussion Reason of abandoning Involving movement
200	Xid: influence same factors in the photography.	Confirming
201	Ke: we mentioned example, - jumping, right? Maybe jump is one movement, every time we jump there will be a picture. But this is the most simplified, I can imagine it won't be so much interesting. But there is a lot space left for discussing. Firstly, what movement is worth shooting, second in what would we photograph the movement so that it is appropriate. There is a lot, e.g. angle . You can imagine i have camera all over my body, which camera is taking picture when I am making certain movements? Does the camera on my foot shoot or the camera in the air. This is one possibility. Another is other elements aperture, speed of shutter , etc.	Mentioning example Rejecting too simple idea Raising questions as prompt Proposing new function
202	Ke: And then I suggest that you don't stay in the classroom and think, let's go out and play.	Encouraging "playing" outside
203	Xid: let's go out. XM being like this makes me very anxious. He says to me "what you want to do is like this, right?"	feeling anxious
204	Ke: It's quite normal, I can understand.	Understanding difficulty
205	X; can you understand the idea now ?	Asking for understanding
206	Ming: yes, like the interaction expression is related to camera movement and many more ways ?	

207	Ke: you can see here the problem of communication here is you (XM) think about specific things, and you (Xid) are thinking about generalised ideas, abstract concepts. I think the core problem of interdisciplinarity is not the specific problem, but the communication itself. Your languages are different from my point of view. You are using a language resulting from your past training, which is very good, is helpful for our disciplinary thinking. We need this ability. But the core ability is being able to understand each other. That's why I asked you(Xid) to try to understand his work, through his language, so that you are more familiar with his language.	Pointing out problem in communication Concluding the difficulty Language different Understanding as core ability Acting to understand
208	Xid: In fact I think he is very clear, I can understand what he want me to understand. But what he omit, is still missing. He extract the some elements, very concisely, very clear, (but not what I want)	Unilateral understanding
209	Ke: we need practise, if you want him to understand you, then you need more than words. You need to draw, to show examples. It's much easier. It's a game of a group, we cannot let anyone do everything. I suggest you go out to see if there will be anything interesting. Even you don't get anything, it's still OK. For my own projects, I spent many days trying, and I get nothing. But finally I took one picture that is good(shaking head one).	Advising how to improve communication Allowing empty result Referring to past experience
210	Ming: let's go out.	Going out
211	Ke: let's see this, (showing camera projects).	Showing example
212	Xid: thanks.	
213	Ke: so the implementation is not the essentials.	
214	Ming: it's the expression.	Emphasizing expression
215	Ke: It's not because implementation is not important, it's quite important, but within two days, it shouldn't waste you too much time.	Limit of time
216	Xid: I think it's quite interesting even without the implementation part.	regarding interesting without implementation/feasibility issue
217	Ming: the prototype is not of so much interest itself, because it requires...	Explaining Prototype function
218	(Joel coming, asking for explanation)	
219	J : what do you want to do with the camera?	Asking about progress

220	Ming: the camera is the tool to produce the time. Using the movuino to detect your motion or gesture, and use that information to control the camera may capture some special moment, such as we are doing some special moment that consists something unusual, might be fun or a kind of art.	Explaining project Capturing moments Resembling art
221	Jo: but I see in details how you do this. You are going to film or capture and then you will have a kind of picture or movie coming out of this ? my question now is what are you doing with this kind of image.	Confusion about function
222	Ming: we are just creating them and show special moments.	Clarifying on the purpose
223	Jo: the question now is how you prepare the situation before you do the picture. When you do the picture, there is something going on.	Asking about the scenario
224	Ming: actually, there's some parameter in the camera, such as focus distance, aperture, iso, we consider using movuino to get the data of the movement, and then use the data to control the camera. Using the information to change the parameter and produce some unusual picture.	Clarifying
225	Jo: Ke told me that you have difficulty with the technology, what is that ?	Technical difficulty
226	Ming: in this system, there are two key device, the movuino and the camera, we haven't had a good idea how to do send the data to the phone and change the camera's parameter. After discussion, we want to take pictures to illustrate our idea.	Explaining working progress
227	Jo: I do agree. Once again, if after this week, you want to continue, you can work on it. But now one minor technology problem might take hours. It's nice also that you have this evolution of your project from yesterday to today. I like it very much.	Confirming Approving the progress
228	Ming: we have discussed on the formal idea, there is some problem of that idea.	Problem of previous idea
229	Jo: it's just perfect to do that, sometimes you work on the project and then you just decide to change it. Good.	Confirming changing
230	Ming: Renju, I think yesterday we should buy the soft camera fixer. Do you have it. Let's go and play.	Going out
231	2016.12.15 in the cafe, after prototyping (R, Ming Xid & K)	

232	Ren: Normally, when we take a photo, it's always the photographer who controls the picture(camera), we are asking if we can let the subject to control it. For example, if the subject shakes, the camera will shake. We chose to make videos rather than pictures. The camera is here, no one is touching it. And then the model moves, which triggers the camera to move. We proposed this idea.	Explaining rationale Subject as Photographer Shake effect Preferring video
233	Xid: Because photos are not very expressive, (we took videos) let's see what we've got.	Why video
234	Ke: looking forward	
235	Ke: Wow!	Exciting
236	Ming: The whole picture will rotate,	Explaining the video
237	Ke: very cool !	Exciting
238	Xid: you know, he wants me to rotate a whole circle. But my hand can't rotate to that angle	Potential effect
239	Ming: look here, we tend to enlarge the small movement by moving the camera.	Presenting effect
240	Ke: it's very good, very very good !	Loving the idea
241	Xid: this is the series of rotating.	Collection of effect
242	Ming: A lot the phones, they have double camera ...	
243	Ke: Do you have servo ? if you have servo, you can make the prototype. You can have a protection case for the phone, which attached to the servo. Once the skateboard rotate, the servo begins to rotate the phone. You can make it. Put the movuino to the skateboard.	Presenting technical solution to make prototype
244	Ming: We were thinking about presenting the idea with videos. Renju suggested that we do a live demo of this. In fact I think we can also make a software to rotate the video.	Explaining thoughts on presentation Live demo as presentation
245	Ke: i think it's already very cool .	Approving the project
246	Xid: We have other effect.	Presenting more effect
247	Ke: I think you can try different speed. It can move quite slow, you are not unstable, and then it becomes unstable.	Proposing other effect
248	Xid: we have effects like this.	Showing effect
249	Ke: you can try also when it's extremely fast.	Extreme effect
250	Xid: then we need the servo, my hand is not as fast.	Requiring servo
251	Ke: hahaha. But do you have any servo.	

252	Ming: I am afraid the servo is not powerful enough to rotate the phone.	Questioning feasibility
253	Ke: A good one will do. What you need, you need a phone case, a servo.	Confirming feasibility
254	Xid: we have other sway effects .	Presenting effect
255	Ke: what else?	Asking more
256	Xid: these are not good enough. You can see me taking videos of them. This one. They are jumping and the camera is also jumping. <i>Isn't it fun ??</i>	Presenting other effect Jumping effect Feeling Fun
257	Ke: So good, you can have a series of them. You know there are big phone cases in the market. Your product can be one of them, a really big one that has a built-in servo, which move the actually phone. You can hold the big case and then phone will move automatically. You can play it outside. Perfect.	A collection of effect Proposing technical solution
258	Ren: we call it “fun with movie”, referring to the TV show “the big bang theory” There are two goals - 1. Let the subject control the picture, 2. we set three modes of fun movies. - three modes that we just saw. And just now, the enlargement effect that XM mentioned before is a kind of visual effect, can't be categorized into one of our goals, it's just a visual effect.	Naming the project Presenting rationale Categorizing rationale Excluding effect – just visual
259	Ke: you can totally say it is a programmable design. We provide several modes, very fun. But users can play themselves. We can open the imagination to all those who buy this. BTW, I just thought about a name, I think it's interesting: we can call it : you jump, I jump.	Promoting more openness – programmable Naming and joking
260	Xid: (laughters) sure.	approving
261	Ren: maybe we can try this name.	Agreeing with hesitation
262	Ke: I like it, imagine the subject jumps, and then the phone jump after they jump. What kind of videos do we have.	Imagining effect
263	(watching prototype videos) laughing	Enjoying watch
264	Ren: can we realise it ? I think the audience would look forward to our final tangible result.	Urging to realize Tangible result
265	Ke: sure, i think so. firstly, you need a phone case, and then fix the phone case to a servo.The servo should connect to a bigger structure, which you hold in your hand.	Presenting solution
266	Ming: looks like a cradle head.	Resembling to cradle
267	Ke: exactly.	Confirming
268	Xid: we can choose one effect to realise.	Simplifying prototyping

269	Ming: that way we use the front camera ?	Technical detail
270	Ren: what is a servo.	Asking detail
271	Ke: a machine to rotate. (Ke drawing)	Presenting detail
272	Ming: but the rotation in centered here.	Questioning implementation
273	Ke: i think that doesn't matter, when she uses hand, she doesn't know where the center is.	Solving problem
274	2016.12.16 heated discussion in the classroom (R, Ming Xid, Ke & J)	
275	<i>(the team already argue for some time about the naming and core idea of the design. There is no recording of the discussion. Xid and Renju had very different opinions on the naming of the project. Renju proposed "jumping video" which Xid believe is less fun and less depictive than "you jump, I jump". On the other hand XM proposed to use software for the same effect (partly because there are some difficulties in making the moving phones), which Xid also disagree because she thinks the core of the design is the association of the movements, and using software will weaken the association, since users can't see directly the "you jump I jump" effect. The discussion was very heated, so both Joel and Ke came to help resolving the tension.)</i>	Arguing on the core value of the project Debating on Naming Alternative solution Highlighting association Heated discussion
276	Jo: People like Ke match together, because they have both background of science and design, which is really rare. The other thing is people like me, when I work with designer, and major difficulty is how they enter the same question from a completely different perspective, but which is still extremely interesting, but the good point is to match those perspectives and make something new, and that's the fun of it, never say it's easy. It's very difficult. Between scientists, engineer and designer, there is always tension, because you never agree. But you accept that you don't agree, and make something new out of it. When it comes out, you doing something cool, because it's good.	Multiple background Bearing different perspective Creating as resolving conflict Difficulty in agreeing Making things is good and cool
277	Ke: I think this interaction between science and design you talked about already happened within the group.	Observing interaction
278	Jo: Yes, I know.	Confirming
279	Ke: let's discuss about ... so if the servo aren't available, we can use hand to move it, forget about the	Discarding "servo" – unavailable Important to move

	servo. But I think the movement of the camera is most important.	
280	Ming: so we can design this structure...	
281	Ke: Firstly, do you think the movement of the camera is important? I think, the movement is important, but since you say you want to use software for the same effect, so I want to ask your opinion. Do you think of this idea because it's hard to implement? Or it's just you think that they are the same?	believe movement as important asking reason for different understanding
282	Ming: hard to implement.	
283	Ke: but what if it's easy? Do you think it's equivalent ?	speculating and digging true reason
284	Ming: Yesterday we saw the cradle head can rotate. Only the control is more stable, so I am thinking about alternative way to fix it.	referring to example avoiding the question
285	Ke: but you don't have the knowledge ? I don't have either. But let's assume we have the knowledge. You propose a good question, that we can do it with software. What's your understanding of this?	pushing for real reason
286	Ming: When i think about this design yesterday, to use the mechanics, firstly, I really can't make it, secondly, I thought two people are taking photos, so that the photographer would have his own traditional way of taking pictures. If the camera is moving, it might change the regular way they take picture.	giving reasons not able to making within time transcending traditional way of photographing
287	Ke: OK let's discuss together.	proposing group discussion
288	(the girls are talking about names)....	
289	Xid: I think our product's focus is the association so "you jump, I jump" can highlight the association	naming presenting "association" as meaningful
290	Ren: but the users wouldn't know the activity then	naming not understandable
291	Xid: but if you put "jumping video", it's still strange, why would it jump?	feeling awkward naming meaningless
292	Ren: "Jumping video" is the visual effect. How do I know what you meant by "you jump I jump"?	naming not understandable
293	Xid: but "jumping video" doesn't sound catchy. will be disadvantaged when selling. Secondly "jumping video" doesn't have a reason. Our point, the focus is the association, not that it can jump. Everything can jump.	naming not catchy naming meaningless emphasizing on "association"
294	Ren: but what if users never heard of the background of "you jump I jump", would they understand?	naming not understandable lacking context

295	Xid: But “you jump I jump ” is just an association.	repeating “association”
296	Ren: jump what ?	not understanding
297	Xid: then it makes you curious, so it is like a slogan.	name appealing
298	Ren: but it can’t be a name of a project. The title. A title would let people know what it is, what it refer to.	naming should
299	Xid: is there this requirement (asking ke)?	asking for requirement
300	Ke: I don’t know, you guys can discuss. I think the discussion is very interesting.	not providing answer
301	Xid: Renju is 又红又专 (holding a orthodox mindset) , she’s from Mechanical Engineering	describing group member
302	Ke: So what?	
303	Xid: Therefore she is 又红又专 , I can’t persuade her, making me really annoying	expressing feeling annoyed impatient
304	Ke: She has the same feeling as you..	imbuing balance
305	Xid: No, I am really upset, because the core of my idea is that the two movements have connection. So that “you jump I jump” can illustrate the connection.	feeling upset not able to communicate emphasizing on association
306	Ke: OK now we have two discussions.	two discussion
307	Xid: No hurry, one by one, if it’s just jumping video, ...	
308	Ren: Didn’t we agree to “jumping video” last night?	decision already made
309	Xid: I was just tired to argue, and didn’t know how to say it.	feeling tired in communicating
310	Ren: So the discussions last night, are they all invalid or just this part?	questioning progress
311	Xid: Leaving the others, now we only focus on this.	focusing on naming
312	Ren: Why we focus on this small thing. I don’t think our problem should be the small thing. We need to make the prototype.	naming unimportant proposing working on other things
313	Ke: you are from mechanical engineering ?	asking background
314	Ren: yes, the school of mechanical engineering.	
315	Ke: ah.. (to XM) then why don’t you ask her yesterday ?	
316	Xid: (explaining to R) XM had some problems with mechanics.	explaining missed context

317	Xid: No, actually, for me, the original idea is the associated movements. If it is me alone doing this, I might not even extract the specific left-right, sway, and jump modes. I think it is good for you to extract these modes, because it looks more clear this way. But you don't need to make the title the same clear, because for me, the content is already very clear.	explaining originality imagining individual work leaving out specific effect approving more clear effect unnecessary to name in clear manner
318	Ren: for you yes. But it is for user.	naming for user, not designer
319	Xid: but won't you understand after seeing the video.	understanding after video
320	Ren: We should stick only to designers' own idea. And also, this is a group project. Furthermore, we have already discussed it yesterday.	giving reasons for rejecting naming for user, group disagreement, already decided
321	Xid: don't mention to me about last night.	feeling frustrated and angry about past discussion
322	Ren: And now you want to change.	
323	(there are some argument between the two girls about the night before, not a lot of content.)	arguing meaninglessly
324	Ren: Actually, I put down "you jump I jump", but you disagree. And then it was crossed out.	recalling past discussion
325	Xid: I didn't cross it out.	denying own decision
326	Ke: OK, how about we listen to the third member - XM, how he like the title.	inviting third member to judge
327	Ming: We just don't name it?	proposing no naming
328	Ren: No, we need a name for presentation for poster...	rejecting, must have name
329	Ke: what exactly happened last night?	asking for details on past decision
330	Ren: in the beginning, Ke proposed the idea of "you jump I jump" and then we all agree. And then Xid disagree.	recalling discarding naming
331	Ming: we agree to use jump camera	
332	Xid: And I disagree to jump camera	disagreeing
333	Ren: in the very beginning, Xid proposed the idea of "fun with movie".	initial proposing
334	Xid: yes i proposed, you can also use "fun with movie"	
335	Ming: and then we say how about combine the two - comes "jump movie", and then, I said movie is not the right word, should be video.	combining both propositions changing wording
336	Xid: so you proposed it?	clarifying decision
337	Ming: yes.	
338	Ke: and then you crossed out "you jump i jump"	discarding name
339	Xid: i didn't agree to it.	remembering not agreeing

340	Ming: actually, last night, I didn't understand "you jump i jump", i heard of it, but didn't know the story behind.	not understanding the wordplay
341	Ke: I proposed that because Xid showed me a video where Ren was jumping, and the camera was also jumping.	explaining rationale for naming
342	Ren: So then we borrowed "you jump i jump" from the TV show "the big bang theory", right.	borrowing naming
343	Xid: no, "fun with movie" was from the TV show.	correcting misunderstanding
344	Ke: "you jump i jump" is a famous line from the movie Titanic ...(explaining the story) ...	explaining wordplay
345	Xid: I think it is usable, first it's more fun than jumping video,	feeling fun thus usable
346		
347	Ren: The reason why I disagree with "you jump i jump" is like Xming's point: because I don't know what it means.	naming not understandable
348	Ke: I think it is a very valid point.	approving
349	Xid: I don't understand why you don't understand.	not agreeing
350	Ming: because the movie is very old, the young people, who are our potential users, might never see this movie, we have to consider them. If two of us three didn't hear about this, we can imagine the title is not that catchy as you imagine.	wordplay out of date not catchy as thought
351	Xid: you can't use yourselves as an example.	self not representative
352	Ren: I've seen Titanic twice, but still I am not familiar with the line, but I can recall the scene when Ke mention. It's not self-explaining at first sight, maybe we need to explain a lot, and then people realise the background story. Why don't we use a simple way to let people understand it at first sight ?	having seen the movie but forgetting lines understanding when seeing
353	Xid: Because there is no need. If we were told something that we don't know about, we will keep the question in mind, and then when we explain it with videos, and then they got the idea, with a surprise. There is a change of emotion. Only the jumping video is very dump.	not knowing inviting more curiosity emotion arousing
354	Ke: it's a very good discussion, for Xid, "you jump i jump" is symbolic and metaphoric slogan. For you two, it is hard for the user to understand. Actually I come across similar situation. Sometimes, I think of a name, and I ask advice from many people. And the most	approving both rationales referring to own experience asking for many advice

	common comment is “can you make people understand” “is it very relevant”.	
355	Xid: OK, what is your first impression seeing the title “jumping video”	Asking for first impression
356	Ren: First of all, it’s a video	
357	Xid: a video that jumps ? but the content is not a video that jumps. The result is a jumping video, even if you insist on a realistic title, jumping video is not appropriate, because it doesn’t concern the second element - the movement. Where is the movement. It only depicts the result.	Not agreeing on video
358	Xid: I need Ke to translate. I need translation even in Chinese.	Asking mentor for help
359	Ke: it’s exactly the same question as before - what is the final design ? is it the video or the process of photographing ? or the association? Actually XM and me we were discussing the same question, and now we can merge the two discussions. Interesting.	Asking core design Implying meaningfulness Proposing to merge conflict
360	Ke: Because the mechanical structure is hard to implement. XM proposed to use software to imitate the jumping effect.	Explaining conflicts
361	Xid: we can’t say the jumping effect is no value, but the value is very small. The core value is the association. You give it away, then it is not attractive in terms of innovation. Do you understand this point ? Anything can jump, but the association is rare. Establishing the association between two things is a process of design.	Judging value Explaining meaningfulness Providing reason for argument
362	Ke: this is exactly what I said to XM, and XD didn’t hear me, and she had the exactly same idea. We agree on that - the core innovation of the idea is not the effect, is not when meituxiuxiu (an smartphone application like photoshop) make you look better, but the in the process, the photographer and subject enjoy the playing experience.	Agreeing on argument Explaining innovation Giving examples
363	Xid: the essential is the association and the better effect is the better presentation, but not core. You can’t say it’s unimportant, but ...	Explaining meaningfulness Comparing
364	Ke: but XM raised a quite good point when we two were discussing, what was it ? your last point?	Asking for repeat

365	Ming: that normally people have own regular habit of photographing, for example xx take pictures us, he would focus on us and observe our moving. Assuming if we have the movement of the camera when the subject move. It might bring difficulties to the traditional photographer. About the user habit.	Proposing experience difficulties User habit
366	Ke: this point is quite interesting, we never discussed it before.	Validating question
367	Xid: can you explain more?	Asking for elaboration
368	Ming: for example, when I hold a DV, I will hold like this, like this angle. If the DV moves, it will interrupt my regular habit of shooting. It will bring confusion.	Explaining with gesture
369	K; did you understand?	Asking for confirmation
370	Ming: because when you take a picture, you will have certain point of view in mind, and then you already set the point of view, and then the camera moves, so you lost your point of view, you can't control the picture. For example, if you want the picture to move left, but then the camera moves to the right, you will get lost.	Elaboration
371	Xid: ehhe.	Thinking
372	Ren: smartphone will move according to the our movement. Using the servo to move the camera. So the servo can adjust the camera movement.	Explaining the function
373	Xid: then we first move in small ranges. Let's first keep it to an adjustable range.	Proposing solution to the difficulty
374	Ke: I think the question is not only looking for practical solutions. Let us paraphrase it using my own words: it will bring confusion to a user's old shooting habit, is that so?	Denying practical solution Upgrading to abstract meaning
375	Ming: Or it is contrasting to human nature.	Reaffirming
376	Ke: what do you think ?	Ask for idea
377	Xid: I don't think it's a problem. There's a lot of anti-instinct design.	Disagreeing on the nature of difficulty
378	Ren: in the beginning, the user might not get used to it .	Reinforcing the difficulty
379	Xid: and this design . I really haven't thought about its practical value. Or the practical details. Do you need to go that deep? Considering its value	Focusing on value – not practical
380	Ke: OK, I think the point is to make people uncomfortable.	Proposing purposive discomfort
381	Xid: exactly, I meant that, because it is a anti-human nature design.	Agreeing on purposive discomfort

382	Ming: I think there is another point that Joel mentioned, that taking video is a good way to recording the movement(speed) of the subject relative to the earth. If you add too many structure, the video can't record the accurate speed.	Proposing new function
383	Ke: why do we need this accurate speed?	Questioning
384	Ming: for example the speed of movuino and speed of the camera	Repeating
385	Ren: like we can measure the relative movement. From physics, they are in relative move. Maybe we can capture this feature, so that we can measure the speed.	Adding value from physics discipline
386	Ke: but what for ?	Questioning purpose
387	Ren: I mean the principle, it is the relative movement.	Mentioning physics principle
388	Ke: So first, what do you understand it is, your experiment, your discussion, your three understanding of the project.	Asking for clarification of the project
389	Ren: in fact, can it be like this, from technology pov. It can detect the center of the picture, so that if the photo is constructed unbalanced, the camera would move automatically to put the focus center to the real center. .	Proposing function from Technology perspective
390	Ke: but why we need this ?	Questioning the purpose
391	Ren: can that people would understand better the rationale of the design , which is to capture the center of mass of the picture. Because normally people would ask why the camera move according to the movement of the subject. People wouldn't understand what we try to express here. However, if we add the concept of center of mass, then the people standing here, the picture is not balanced, and then camera would automatically adjust so that the center of mass is balanced.	Explain the purpose for the function. Adding physics concept – center of mass
392	Ke: i can understand what you mean. What do you think?	Expressing understanding
393	Ren: it can automatically chop the picture. We did a poster, it's like this. The idea is to chop the picture, and the picture can have a good balance.	Proposing function to chop picture
394	Li: so we now just use software right?	Asking for project detail
395	Ren: I am just saying. See, in the original picture the subject is not in the center. So the camera keep adjusting its angle so that the subject can be in the center.	Repeat rationale

396	Li: how do you tell the center of mass of the picture. ?	Asking technique detail
397	Ren: see if we can have a function.	
398	Li: i don't get the center of mass... is it visual center?	Asking technique detail
399	Ren: because let's recall the video last night. When I jump, the camera also jumps, which ensures that I am always in the center of the picture.	Explaining jumping effect and center of mass
400	Li: For example if the subject is leaning, the camera should also leaning.	Proposing special scenario
401	Ke: any comments?	Asking for comments
402	Ming: I think we need to go back and rethink the scenario. In the beginning, we proposed that it was a big room where there is a automatic camera. E.g. if you move in some way, the camera would rotate and trigger a picture. Now we omit one discussion: whether it is a camera standing there or a hand held camera for outside ?	Proposing rewinding Reminding initial scenario Asking for using scenario
403	Xid: first.	Answering
404	Ren: so one person can finish all the shooting.	Confirming
405	Ming: are you sure ? because the first situation, the camera is hidden, so you won't see the camera.	Asking for confirmation Pointing our controversy
406	Xid: no. it can hide or not. When we can to hide it, it's just a setting possibility.	Either way is ok, controversy not relevant
407	Ming:whether you hide it or not, the subject just move, there is no one operating the camera, you just get the final result after the processing.	Explaining the controversy
408	Xid: i didn't get it.	Not understanding
409	Ming: we were discussing on why the subject moving would lead to the camera's moving. One opinion is that the photographer who is holding the camera can also feel the interaction or joy. But if you just fix the camera, and the you are moving, in fact the camera's movement won't be very impressive. You just get the final video that has a effect.	Elaborating the controversy Explaining using scenario
410	Xid: Ah, this ... I think.. First of all, the details, I didn't go that far. If we are now discussing the details, I think it could be me myself playing with the camera or you can hold it. Actually i didn't think about how it moves, the exact scenario. So you think there is a lot of difference in this two modes	Ignoring detail Proposing new scenario – self playing.
411	Ming: what?	
412	Xid: the two modes you just mention. Is there a big difference? We can combine.	Proposing merging as solution

413	Ming: The final result is similar, but the process is different. If it is a hand held, the photographer can see the camera is vibrating or rotating, which leave them a nontraditional feeling of the photographing. If it is fixed, the subject being photographed doesn't feel the movement of the camera, you are just focusing your movement.	Pointing our experience process difference Movement not associated
414	Ren: so now we are going back to the question : do we make the phone move or not? If the phone move, what if the photographer can move the phone, then we don't need this machine. So the effect we need to have, could be the camera is not moving and the picture is moving. It might have bigger effect. If the camera itself is moving , in fact it is a physical effect, to make the video a bit .. dizzy	Asking key function – movement of camera Focusing on the effect .
415	Ming: no matter you do post-processing or you move the phone when taking the photography, the video you get is the same. Maybe the video is bigger when the phone is moving, because it hasn't been chopped. So the final video, the feedback to the subject are very similar. The difference might exist, when someone is holding the camera, the interaction might influence the photographer.	Same effect with different approach.
416	Ming: So we have two modes. One is phone moves, the other is the phone doesn't move and we add post-processing.	Proposing inclusion of both modes
417	Ren: how do we differentiate the two modes. ?	
418	Li: from the implementation perspective, the post-processing approach is easier. It might sacrifice some effect.	Comparing the two modes from easy of difficult
419	Xid: in the beginning I think about the first mode.	Preferring one of the mode
420	Ming: Last night we first think about the first mode, but implementation is a problem. Ke's point is the movement of the phone would influence the photographer, providing interaction. Like if you hold it and you dance, and camera is moving, so the camera has minor interaction with the photographer. It's the difference. And then the difference lead me to think about the very first idea, where we don't have a photographer. So this difference was not considered at all. If we base on Xid's idea in the beginning, i think there is not so much difference. So we can consider the not moving the camera.	Mentioning the difficulty of implementation Reminding the original idea Proposing one of the function

421	Ren: so do we propose a good idea or do we make it ?	
422	Ke: you don't need to think about the implementation. You only consider the design or the idea.	Focusing on design
423	Ren: if like this, I think both can exist.	Proposing both
424	Ke: not necessary the first mode, you can discuss which one is better.	Asking for comparing
425	Ren: if it is only concept, I think we can keep both.	Proposing keeping both
426	Ming: the first, the demo itself is difficult.	
427	Ke: you assume that you solve any technology problem. The problem in implementation is no problem. If you have time, you would solve it as well.	Not considering implementation problem
428	Xid: don't you see structure that can make the camera move like this ? you don't need to think too much on the structure.	
429	Ke: for me, my opinions : I think software is meaningless, because... not straightforward. Why the movement of mine would lead to a video like that? I don't see the causality. You can take the data, and then post-process to get the effect, but why? Why would i add this specific effect, it is not straightforward. The movement of the hardware is seen by our eyes, everyone sees it, it is moving, this is about everything. Many arts is not understandable, why, because it is not	Expressing meaningless Explaining reason – not straightforward Asking why
430	direct. It forcibly made a link between two things. Why would I have this link then ? You three know, because you went through this, you played and generated the idea. But to anyone who hasn't seen you play for yesterday afternoon, how would they know. See here in your video. The first video, I am rotating my skateboard, and then the phone is rotating, so I got this rotating effect. If the phone is accordingly rotating, you instantly get the point, get the association. At least you know how this video is produced. What if I only give you this video, I am rotating my skateboard. You never know why the video is rotating, you don't even know it's the movement of the skateboard that cause the rotation of the video. If there is no physical movement of the camera, there is no such association. Your point doesn't exist, your design never exist.	Asking reason for function Thinking from the user Mentioning example Making strong assertion on meaningfulness
431	Li: but Renju mentioned that we can also rationalize the design by saying it put the subject in the center.	Mentioning function
432	Ke: I don't think the rationale exist.	Denying function

433	Xid: me neither.	Agreeing
434	Ke: firstly, why should the subject be in the center for a photo? I can give you an example, there is one video in the photodrama workshop. This guy tied the camera to a two meter long rope , and then rotate the rope horizontally, him being the center, camera facing him. And then he got a video, and he is in the middle of the picture, not moving much, but background rotating greatly. OK, now I only give you this video, you see the effect, but you don't know at all what he want to express here, right? If you haven't seen the other video shooting how he played with the camera.	Questioning reason Using example
435	Ren: It makes sense, let's move the phone then.	Expressing understanding
436	Ke: I think the core or the meaning of the project is ..	Reaffirming
437	Xid: is to express this association.	
438	Ke: is this association. Just like what you say, you want the audience to understand what it is, a video is not enough. Think of that example. Do you know how he made the video when you just see video, do you really know what the point there. But once you see how he made it, you understand immediately, and then you get the idea, and then you find it interesting. So the point is the final video or the two added together?	
439	Xid: the point is the association, I from the very start stated that.	
440	Ke: but you need express in a way that they can understand.	
441	Xid: OK.	
442	Ke: of course you need to make comment, and you also, if you disagree with me, you can also propose it.	
443	Ren: the association is really important, I now realise our project, the most important is the association between the subject, the photographer and the phone. But then not only these three, we also need to show to the audience. Let them know about the idea. So I believe the video and association should combine.	Confirming on the final meaning of the project

A2. Interview and Coding

A2.1 [OF1-1] Interview Ming

Transcription	Coding
Ke: Hello, this interview is for collecting your opinions upon this workshop we just had. Ming: OK Ke: Can you introduce your background? Ming: OK, I studied optics and electronics in my undergraduate, which is applied physics. Ke: Can you tell me your most impressive projects in your undergraduate? Ming: The first one is to build a 3D microscope with light field camera (e.g. <u>Lytro</u>), improve its optics for biology tissue imaging. Including optics, biology and algorithm. Ke: What was interesting in this project? Ming: (In the group) We used to study applied physics, applied optics (theory). This project is the first time we bought lens, we set up the light path ourselves. In this way we could understand better, many knowledges not taught in class, we could associate (the knowledge). There is a lot of work, and we managed to finish it step-by-step. It functioned at end, and we processed the images as well. We learned light path design, microscopy, light field , biology knowledge, light platform experience, etc. Ke: Are there any other projects you want to share? Ming: When I was in second year, I did an internship in a company in beijing, now merged into xiaomi. There are many Ph.Ds with different background. Occasionally they invite design professors to share their ideas. I felt their research is interesting, not only technology oriented, sometimes we consider human society as well, It's attractive. Before that, I had another internship in the National Optics and Electronics Center, there	optical technology bio-technology applying theory to use independent working truly mastering knowledge and gaining experience functioning as success learning multiple knowledge in making a project interning inviting designer to tech company feeling interesting beyond tech considering societal issue feeling attracted

they were working on basic technology research, which I am not very interested in. Ke: So in the Beijing company it's different. Ming: Yes, in fact every week, they have a brainstorm ... technology review.. (..not clear) . The company is a patent operation company. Every week, staff from different background gather to discuss on their recent research and interesting technology they hear about. Like an weekly meeting, but because their backgrounds are very diverse, so it's more interesting. (any example?) Glasses, with projector, projected to retina, so that people can see the screen(voice not clear). Another one is a ball on hot water, they can control the movement of the ball by controlling the temperature of the water, kind of related to touch screen. Ke: Do they have designers in the team? Ming: they are mostly phd (on science) discussing together, they don't have a designer, but they used to invite designer for a discussion. They would consider human side and application, but many of them is also pure technology. It's kind of mixed, you can not define. Ke: OK. So, I remember you participated in one workshop with a Denqing (a designer), how do you feel about him? Ming: He likes things that are expressive, sometimes when we proposed him an idea, and he would think it is too normal, not expressive, not powerful enough, and he would push us to something that is more interesting, I like this sense of his. A friend who knows him says Denqing is now trying to find applications for his work. His courses were a great experience. Ke: So what is impressive working with him? Ming: Keep saying no. We kept coming up with ideas that ourselves are satisfied with. But after a second thought in the group, we found these ideas were not good enough, or someone else already had them before. So we had to develop further. (What was he pursuing?) An emotional expression. Every group he gave different suggestion. For our group, because one of the group member is medicine background, he tried to push us to think about pills. He likes to combine two different things. He dares to really connect two very distant things and dig deep. More	feeling boring in pure tech brainstorming regularly sharing of divergent perspectives state of art tech interesting and fun technology pure scientist group inviting designer for discussion mixing perspective mentioning a design teacher liking expressive things dislike too normal idea require powerful and expressive idea trying to apply liking the experience constant rejecting to ideas self rejecting - not good enough or not original enough emphasizing on emotional expression

specifically, he pushed us to think about illegal and conceptual ideas, sometimes weird ideas. For example, we proposed to use patches to affect emotions, which might violate some laws, but in design and art, it's acceptable. When he comes to us, he always brings the artistic sensitivity. Ke: How do you describe his design? Ming: magic and fantasy. Ke: Let's talk about the workshop. Can you tell me the story of your group? Ming: The first day, we randomly grouped. We didn't specify what we want to do. The next day, in the beginning I thought light is interesting. I proposed the idea (lighting for selfie), it looked fancy and interesting, we could try. Then we went to huaqiangbei, and realised that this idea is not so closely related to movement. So we kept discussing and find that the idea before have two elements, one is the light and movement, another is the lens and movement. So Xid proposed, we could use movement to control the configuration of the lens to change movement, which lead to the final idea. This was the whole process of our projects. Ke: What were the most impressive moments of the process? Ming: When you asked us to stopping talking and go out and talk pictures. When we really went out, many strange effect came out more than we could think of when just talking. We didn't have any machine to move the phone, so we move it with our hand. We assumed some movements of body will trigger the movements of the phone. And then demonstrate the video. All of us took turns to take the video and being shoot. Ke: What were you thinking when being shoot? Ming: The weather is good! Ke: What other moments impressed you? Ming: Another moment is when you help Xid explain her idea (about the artistic value of random movement), it helped us better understand the idea. (more specific?) For example, in the beginning, Xid expressed her idea as a scenario where there is lens and curtain and the camera can	connecting distant things digging deep daring considering conceptual even illegal things. illegal but concept acceptable in art imagination feeling fancy of the lighting idea. not relating to movement extracting elements movement to control configuration going out helps generating more creative effect taking turns to prototype

capture your action. But she didn't specify the reason, what is the artistic expression here. If it is random, we didn't get the idea. And then later, when we get the point to have some randomness in the artistic expression, some augmented effect of certain action in the video, and then we gradually understood the design. Ke: What do you think of the whole workshop? Was it difficult for you? Ming: I think the most difficult part is expression. The ability to express my own ideas so that other people can understand. Another lesson I learned from this workshop is to keep communicating with our group members. Otherwise, we will probably diverge into two directions very far before we notice. Ke: How do you think of your two partners? Ming: I think they don't agree with each other. I think each of them have their own design philosophy and language. Maybe also because time is limited. Ke: How can we improve the workshop. Ming: Next time it would be good to have a fablab for us to work in. It would be good that in the first day each team can talk to a mentor for advice.	help explaining scenario of specific setting missing rationale pure random making no sense rationale explained with seeing examples. feeling difficult to express keeping communicating unnoticed divergence escalating divergent language attributing to time limit demanding make space more mentor guiding in the beginning

A2.2 [OF1-2] Interview Xid

Ke: Hello, this interview is for collecting your opinions upon this workshop we just had. Xid: I think the workshop is great, because I had similar workshop before, an international mentor came and provided us with Arduino and	

a topic, guiding us to do interaction design. But that was just interaction design workshop, and if you compare the two, I think the this workshop had more practical implication and flexibility. So this one is more interesting. Ke: Can you remember in details the workshop you just mentioned. What did you do ? Ke: OK, the topic is music player. They gave us Arduino to play with. We were assigned with one emotion. Other teams have “surprise”, “dramatic”, etc, and we had “fear”. So we had to design a music player associated with the emotion: fear. So our final design is a music player with the a shark mouth. The mouth is dark and you have to put your hand in it to trigger interaction. The further you put your hand, the louder it plays. Ke: So it is the first time you knew about interaction design (ID)? Xid: No we had interaction design classes in the second year of undergraduate. They taught theory, methods about ID, (there is a lot of them), and then we had a practise on adding interaction design to robots, drones, etc. Ke: So how do you understand interaction design after all these activities ? Xid: In my undergraduate, my understanding of ID is : it is a relation between human and machine - how I acted and it reacted to my action, this association construct the interaction. A good ID is when the interaction makes you feel comfortable. It is an interaction between me and an interface, be it an interface of a machine or a screen. Now my understanding doesn't change much, but there is one change: Now I think the interaction is more important than the appearance of the product. I held the opposite opinion before. Before, though I understood form follows function, but I really think a product should be good-looking. Now I think the essence is the interaction, we should focus on that. Ke: Joel's background is in Physics, how do you perceive his perspective in this workshop	comparing past interaction design practicality flexibility feeling more interesting playing with prototyping tool given topic of “fear” music player making people fearful interaction inside shark mouth knowing theory and practise before relation between human and machine. good design feeling comfortable me and interface change: interaction overweigh appearance focusing on interaction

Xid: I think he is very good. I felt workshop by designers alone are sometimes narrow-minded. Sometimes they constrained themselves. For example, when Joel came to the workshop, and he talked about the relative motion of camera and subject, and the camera perspective of human motion, etc, this is something that I would never imagine as a designer or in a design workshop. Ke: You mentioned narrow-minded, what exactly did you mean by that? Xid: Like a limitation on the range. For example, we see a lot a good product design from architects. Many good products nowadays came from people with diverged background. Ke: What do you think is the reason ? Xid: Because I think design itself is a 理念(concept/philosophy). Because I majored in design, so when I understood that, it made me anxious (about my career). Because I spent four years in my undergraduate, and I learned one 理念, a conceptual idea. You can't say it is complicated, because I believe it could be quickly nurtured under certain environment. The design mind/thinking... maybe.. is something like aesthetic taste, it can be developed if the environment is suitable. The artistic skills are more hardcore, and I don't have them. So it makes me feel anxious. Concept and ideas are abstract and can be easily gained. Ke: How about Joel's understanding of design? Does he gain the concept you mentioned? Xid: I think from his way of introducing the theme, it's very clear and direct thus has the sense of design. (Theme?) Yes, to associate movement with sensors. I think this is very 直指核心(directed to the core). (Why "directed to the core" is design mind/thinking?) eh.... Because, design, although it has a lot of 理念(concepts) such as "serve for the people", but in fact, I think, it is just a kind of 联结(association). When Joel introduced the topic, he try to associate movement to ...(didn't specify), which I think is 直指核心 itself. And concerning how you associate (the movement), in what forms of interaction, this is a design question. <u>So the question itself direct to the core of design.</u>	narrowed-minded with only designers mind-blowing limit of horizon good product from diverged background design as conceptual feel anxious feeling nothingness resembling taste easily gained theme clear and direct as designly design core is "association"

Ke: So let's talk about your project in the workshop. It's very interesting, especially the process. Xid:I think among all groups, our group is the most interesting one in terms of "process". All other groups proposed an idea in the beginning and finished it without a lot of changes. Their ideas were proposed by designers, and other members followed the idea and implemented. We are different, our engineer (M) is quite imganitive, and quite insisted on what he wanted to accomplish. And we, as a group, of course we need to be supportive to group members. We need to try the idea, and if it didn't work at last, we change/modified together. So, we worked together, and then changed together. Ke:Your first proposal is about light right, can you elaborate more on that idea? Xid:in the beginning, the camera is proposed by Ming, our engineer. When asked, he said he want to do a 自拍神器(selfie equipment). So we asked how is your 自拍神器 special, he said it can adjust the lightning automatically. So first idea was just his idea. Ke: And how do you think of this idea? Xid:Firstly, in the market, there is quite a lot of ways to fill the light in photo. And their effects are much better than direct filling light with really light directly to the face. There is many many ways. And then if it is stage lighting, they are very professional, they don't need this. So actually in the first place you can hardly build up the using scenario, can't find where you can use it. Secondly, this design, selfie equipment, should be portal, always for travel, so I think the application value is not big. Additionally, camera has its own flash, why do we need to fill light? I don't quite understand his point, I don't think it is a very good design. Ke: You don't recognise the value of the design. But in your mind, can you imagine why he proposed this ? Xid: I think, because Xiaomi, he personally hates post process. He just doesn't like to to post-proceed the photo, very persistent on that. It's true actually, a high quality photo need professional lighting and angle. It's hard to do selfie with those. I can understand this point. So I think XM he personally has the need to use this . He is a loner, and he often	associating movement is designly interesting process. insisting on ideas supporting team members changing together question originality individual idea as group idea not original enough in the market not as competitive not understanding reason

went out without telling anyone. When he is alone doing a selfie and he doesn't have a good lighting, he must be very bothered. Ke: But this is not so much related to the "movement", the theme of the workshop, right? Xid: exactly, it is something he just wants to do, and we just follows, not so related to the workshop itself. (so have you considered this in the group?) Yes, we have. I particularly mentioned this to him. His answer was: sure it is related, because you need to control it, so you can control with one hand's movement. And then I asked "why you have to use movuino?" and he answered, because it is the requirement of the workshop(laugh). "OK..." so he is quite 神奇. Ke: So how do you relate your project to the "theme". Xid: The theme itself is not so rigid itself. It's just to combine sensors with movement. I don't really think this is a theme, but more like a limit, a limit to the way of thinking. So we can choose our topic. It is quite free. Ke: Then what was your second proposal ? Xid: So, with your help, we succeeded persuading him to change a topic, because the last we couldn't continue. So I had two proposals, first, to use people's(e.g. dancer's) movement to trigger the shooting. It could be a specific movement, not known to the subject. The sensor senses the special movement and then take the picture, since the subject is unaware of the shooting, so their action is natural. XM, however, he understood this idea directly from the engineering side - the implementation. I couldn't remember all, but to me, it seems he understood it as only a process of sensing with sensor, then telling the machine, and then machine triggering the camera, (there is a lot lost). Because for this design we need to complete it with a lot of design scenarios(dance, stage etc), but he omits these possibilities, and the rest is (not valuable) But I also realise it's not enough time to finish the idea and design the stage scenarios within two days. So, as you suggested, we went out and try taking pictures for inspiration. My ideas was actually two steps, the second step, the movement can influence the setting of camera (e.g. aperture brightness, etc) However, my phone doesn't not have	personal preference persistent understanding personal life – loner Strong personal motivation Why is the relation Not understanding Free topic Understanding from engineering perspective The technique detail

those function, so I can only move the phone when we took videos, but surprisingly we found it is an interesting effect. Ke: It was a success right away? Or you tried several times? Xid: Because it's me who took the shooting, so I purposely tried many times with different ways and finally found that if we move the phone according to the movement of the subject, it's the best effect. Ke: What did you try ? Xid: random movement - move in a circle, he rotate himself and I rotate the phone, or adjust the brightness according to his movement : static->dark, move->bright., also the distance to the subject. We had several tries, and focused on the movement, it seemed to be the only good option. Ke: So did you agree on this design when you shoot? Xid: No, it's just me who shoot and tried, and I showed to them the effect. But I don't think they understood what it means, (the idea behind the design). Maybe I wasn't very clear then. Because I was also trying, I couldn't know exactly what is good/bad, so I wasn't able to tell them. So they don't quite understand clearly. But we were very happy jumping and playing. Ke: And then the next day, within the group, you had a big argue. Xid: Yes, and it's inevitable. It was just one day before presentation. Actually we were super behind schedule then, because the third group member in our team is majored in mechanical engineering design. Her mindset is more engineering-oriented. Her talking is very organised, ideas very practical and logical, but these drives me crazy when talking to her. Ke: But why you can't bear she talking in an organised way ? normally it is a good way to talk right? Xid: Because her "organised way" is very limited. I, myself, can also be organised, e.g. the two steps that I mentioned(about triggering and modifying parameter of camera), but these two steps are general , open. If I specify these steps, they are comprehensive, inclusive. If I were to do this alone, I wouldn't present the project in a way that is so	Focusing on scenario Time limit Going out for inspiration Purposely trying Keep prototyping Random prototyping Not understanding Not sure about the results Good emotion Inevitable argument Due to mindset Talking style Feeling crazy

clear, point one, point two and point three. I would not specify how we move, maybe I will just say we move according to the movement of the subject. And then I would show the video, to illustrate how we played it. But she preferred to categorize the movement into horizontal, vertical, etc. She is very organised. Ke: And you think this organisation is limiting? Xid: I think it depends on the necessity. I think what she tried to organise is not necessary. For example, I can explain it in one sentence, why should I break it into so many steps. And what if I don't want to limit the phone to move in these three ways? What if I can have more ways of moving? I don't need to specify into details. Ke: What was the argument about? Xid: Because my idea is quite clear, but the other two not clear, they have different ideas, their own ideas. Even though we saw the same thing, experienced the same thing, but our ideas are still different, surprisingly, still different. We had to try to persuade each other. I told them what was my original idea, and they told me, when they see all of those (videos), what was their understanding of the design. Me, I always had the same idea, to highlight the association. But for XM, the most important is the video looks fancy. For the other girl, it's both the association and the video. However, these are different from what I perceive. I just wanted to show the association (from the movement of the subject to the movement of the phone), if the video is not good enough, we could adjust later. Ke: As a designer, after all this, in what ways do you think you are different? Xid: The focus is different. As a designer, I focus more on the link between human and object, because it is the essence of the world. And then engineering focused more on implementation. They are OK, because we have different backgrounds. After this argument, I find "design" is more than what I perceived. I find communication and understanding is a big part of design as well. How can you quickly understand a person, and afterwards understand their language. It's important. This was there in theory (that I learned), but I didn't take it seriously, because we were all designers, we built up the same language, we could understand each other. But here is different. For designers, it's essential	Organized as limited Comprehensive steps Vague presentation Not necessary to be organized Not interested in details Same thing different ideas Negotiate ideas Videos for supporting ideas Fancy is important Only Association matters Focusing on the link

to know their language, and well communicate to the extent that I can sell the value of beauty. Ke: Do you think they sell something to you ? Xid: Yes. e.g. in the argue, the girl proposed that we can also use software for the same effect. My preference then, was still hardware, because it's physical, straight-forward, and attractive when you can see the phone moving. I think the product is targeted at fans of the phone, and they would prefer a physical peripheral as well. Then she said software can do the same thing. I was a bit upset, because I thought she didn't get my point. But now I think her point is also valid, because, when the hardware is well accepted, this software can be a lot fun too. It might be popular. Then XM, his very direct and insisting perspective also influence me. Ke: What's most impressive for you in the workshop ? Xid: You. Your ability to both work as an engineer and know the value of design. Also your ability to understand different perspective and languages and communicate. And then Joel is always encouraging us, it's very good. Ke: What is your suggestion if we do it again? Xid: Now it feels more like a design workshop, maybe we can find a way to realise the value of student in other disciplines.	Different background contributing to different focus Understanding language No practice experience Understanding within designers Selling value Receiving value Upset about different idea Understanding after Accept more meaning influence of Insisting attitude value of fusionist encouraging

A3. Memo and Coding

A3.1 Memo of Conversation

Memo	Coding
Episode 1. The Selfi Stick (Line 1-28)	
The major discussion here is the implementation problem of the selfie stick. From the post-interview we know this selfie stick is largely an idea of Ming's interests. Ming seems to be very interested in the specific idea alone. The process in this episode follows a problem solving pattern: Feasibility / implementation problem -> proposing solution. The solution has multiple levels. e.g. new function: to make a frame to hide the light new meaningfulness: artistic new scenario: outside, express emotion new technical: folding the selfie stick There are almost no explicit meaningfulness communication. But there is some hint of implicit meaningfulness. 1. Most conversation is around the feasibility issue of the project. There seems to be a consensus on that. 2. Ming was very active in defending and creating meaningfulness for the project. When they face the problem of light being in the picture. His first reaction was to ignore. But when Ren insisted on the problem, he propose to make a frame for the light so that it looks artistic. This proposition does not directly solve the problem but accepting the problem and reuse the problem to add new dimension of meaningfulness. - Introducing new meaningfulness to <i>justify a proposition</i> to the "Project". First of all, Ming must hold some degree of the artistic, otherwise he wouldn't propose that. But we should also be aware the fundamental meaningfulness is not "artistic" , it is a <i>supportive meaningfulness</i> that align with his original idea of the "Project"	Actively involved in the Project Meaningfulness - feasibility raising supportive meaningfulness implicit meaningfulness Agreeing on the meaningfulness - feasibility Meaningfulness - artistic Project -> new meaningfulness ->justify Project

This meaningfulness was not responded by Ren but agreed by Xid. (“Xid: For me, I think if the light have to be in the photo, it’s better to make it look like a frame”) 3. The new function of colorful light was proposed here by Xid. The color element was used in the later episode as a symbol of playfulness. But Xid did have the chance to develop her idea any further, so we cannot infer from the conversation about this meaningfulness. The project idea had a very big problem of little relation to “movement” and was abandoned. But Xid even tried to prototype it himself after the workshop.	aligning meaningfulness no response agreeing on meaningfulness Meaningfulness - playfulness Meaningfulness - new proposition of function
Episode 2. New Proposition (Line 30-60)	
The proposition Xid was a camera system(light and shutter) that can react automatically to the subject’s movement. She didn’t explain why she want to propose the idea, except an intention to borrow some of components from the previous idea, so that Ming wouldn’t think too much. Some of the words Xid uses might imply her underlying meaningfulness, .e.g (L35 crazy). – at least she does believe the craziness is meaningful not the other way around. X was constantly proposing ideas in the first part, she is now the active one. The misunderstanding from L42 started as Ming did not really understand enough Xid’s underlying meaningfulness. Ming was focusing on the specific effect, which Xid believe does not even matter. What Xid believes as important is the association of movements – subject can control the lighting and camera with their movement and supplemented with a playfulness feeling. These two meaningfulness get along as the playfulness feeling is kind of experience and so is the association. But that does not	Meaningfulness - craziness Active and passive Meaningfulness: good effect Meaningfulness : association

align with the Ming's focus on the specific light effect, therefore whenever Xid proposed anything, Ming would interpret from his perspective deeply related to his meaningfulness of effect (e.g. visual effect). As long as Xid does not address this meaningfulness they can not communicate well. This part, in the beginning, I wanted to describe as a conversation of “meaningfulness”. But then I changed my mind, as conversation doesn’t say much about their will to drag the Project to their preferred direction. It is more like “tug a war” of “meaningfulness”. Xid and Ming try to drag back and forth. It seems in this part, no one wins the war. But during the war, both of them tried to explain more clearly their intention and meaningfulness. At the end of the conversation, Xid started to combine. Xid propose spot light and colorful, It is in her mind part of the experience but also proposed because Ming demand specific effect. This is an example of meaningfulness communication change the collective status of meaningfulness and then change the Project	supportive meaningfulness: playfulness meaningfulness not align “tug a war” of meaningfulness back and forth clarify meaningfulness combine “meaningfulness” collective meaningfulness change -> project change
Episode 3. Getting Stuck (Line 61-170)	
The conversation started as Li joined the discussion. From the start we know, Xid and Ming agree that the interaction is interesting, but Ming also mentioned that it should develop more details for the Project, which aligns with his previous view. But Li started from a very practical perspective. His meaningfulness is very centered on the practicality side (e.g. he gave an example of capturing wild animals, a very practical application that looks like Xid's idea). This practicality meaningfulness is very different from Xid's meaningfulness of “fun (even crazy) experience”. But what makes the conversation even harder is that they did not exchange of the meaningfulness level as Li did not join Xid and Ming's previous argue so Li did not know about all the “having fun” statement.	Meaningfulness - practical different meaningfulness lack of communication on the meaningfulness

Li's reaction :” I don’t understand the need. Why there is a camera ?” “it reminds me of some people put cameras in the wild and the animal would trigger it. But I don’t know with human” “looks like it’s becoming more complicated. Rather have someone take the picture for you” Li's reaction shows that he didn't know or understand the “having fun”, just focus on the practical side ”the need” “take the picture for you” X tried to fix the problem by proposing new scenarios: ”rollers taker”, but that didn’t work, because Li still did not think about the fun side. They tried to resolve the problem by working out the specific details, that did not work either. it makes their project get stuck About complication: Li kept rejecting Xid's proposition in this part: he used a vague reason: “complicated.” He felt the Project was too complicated, but didn’t further elaborate on which part is complicated, what’s the reason of being complicated (Li's expression of complication: Line 68, 74, 84, 105, 109) There seemed to be a barrier that stopped Li's meaningfulness from entering the discussion. He tried to repeat about the feeling of complicated, but the lack of examples, and lack of elaboration makes it very different to propose new project ideas that can represent the meaningfulness. Or to combine the meaningfulness. The attempt of the idea of roller staker was not good enough. There is a turn at Line 102-103. When Xid explain a bit more about the rationale, the interesting part and even invite Li to try himself : “The trick is you don’t know your pose when the camera is triggered, don’t you want to try?” Li answers: “i kinda understand. But inside a room, to take a picture of movement is not good quality.” Showing Li started to know better about the idea behind. But he still worries about the practical side of the problem: the “quality” What Xid answers is a direct reference of her meaningfulness : “having fun experience” “Even the quality is bad, it doesn’t matter.”	insisting meaningfulness not understanding new scenario failing to connect meaningfulness: insisting on negetic comment no elaboration no constructive explanation. disconnecting meaningfulness from entering Project “Project” trying to connect fail

Quality does not matter, because it is the experience and the association that matters. It is a pity that even at this point, when Xid talks about “quality does not matter”, Li and Xid couldn’t dig deeper about their different meaningfulness that drag the project to different direction. Li answers “Li: it looks complicated. Some one can take the job”(L 105), which goes back to his old statement, without progress in clarify his meaningfulness. Later, Xid adds more supporting function and meaningfulness “But with or without is a photographer is definitely different. We will act when facing someone.”(L106) Which was also support by Ming “Many professional photographer, one of their job is to take your picture without your awareness”.(L107) But Li does not answer in a constructive way “Li: can we connect it in a smarter way ? looks complicated to me”. (L 109) There is no good or wrong meaningfulness, every meaningfulness might have potential. But there is meaningfulness well incorporated to the group and to the project, and meaningfulness standing alone inside someone’s head and refuse to connect in an easily understandable way. This first part of this episode (L.60-100) features the later status. It is largely because Li’s constant rejection and not being able to understand the other meaningfulness at the same time not being able to explain his own meaningfulness. He mentioned five times about complicated and nearly every time he did not give rationale to back up his statement. Therefore It is hard for the team member to capture and really incorporate this “complicated” meaningfulness behind. Xid tried several times to explain herself by giving examples, and to argue on the rationale, and Ming also tried to work out the detail and supported Xid's meaningfulness. But their attempt did not seem to evoke the echo of Li in empathizing the meaningfulness of “fun interaction”. The group is getting stuck! X finally gave up her idea and asked Ming and Li to come up with their own. And they finally did find an idea all of them are excited about. The idea was started by Ming and was accepted by Xid quite easily, as the idea can easily addressed Xid's meaningfulness of “fun, unique experience”.	function raise direct meaningfulness missing opportunity to dig deeper the meaningfulness little progress in clarifying meaningfulness not constructive meaningfulness disconnected from project or group not giving rationale

“Xid: I never tried. I think we can try. It’s like a opposite design. Normally we prevent the shaking, and now you want the opposite.” (L.130) “Xid: I think it’s a good idea” (L.136) L did not comment a lot on the idea, only an implementation question. Li helped them to try the idea on their phone as prototype. Li made a mistake, he used the video mode instead of take picture. But it turned out to be a stylish video. Ke's suggestion was about the “power” of the interaction. He believed it is meaningful to make symbolic meaning to the interaction. He gave the example of the mouse trap camera. Li showed his meaningfulness of practicality again here by proposing a practical function “shooing jumping”, which is not Ke's intention, but Ke did not oppose to that, he tried to connect to another project that is related.	Project inherently connected to meaningfulness Meaningfulness - powerful interaction giving example to explain meaningfulness.
Episode 4. Mutual Understanding (Line. 171-231)	
We see here in the fourth episode some attempts to increase the mutual understanding. Ming is in charge of the technical implementation part while Xid is responsible for the design part. Ke wants Xid to learn a bit about the implementation from Ming, therefore Ke ask about the implementation questions to Xid. Xid's answer indicated that she does not understand very well on the implementation “Xid: I don’t know how he can implement it with the hardware, I understood his general idea. So all of this is meant for triggering the camera” (L 180) nor did Ming understood well about Xid's idea : “Xid: so what I explain a lot, but he understood very directly. That it is a movement that triggers the camera. Fair enough.” (L.182) in the above complaint, Xid indicated Ming only understands superficially the meaning of Xid. very directly can be interpreted as the implementation level. Only making efforts in the implementation level means Ming did not actively contribute to the ideas at the level of meaningfulness.	Communication on mutual job division supervisual understanding supervisual understanding inactive participation

The problem is multifold. It is because they did not already have a clear project definition. Up till now the idea was still the vague. It is because they do not have time and Ming was focusing on the technology issue. He did have experience on working on the technology so he tried to work it out. Part of him believe working out the technology implementation is meaningful, which is actually not the intention of the workshop: to create ideas and to prototype it. Both the lack of concrete idea and the intention to work out the technology makes Ming inactive in the work. In the following, I told Ming, that the technology is not important. “Ke: In fact, these steps are trivial. It’s limited because we only have this Matt application, but actually what we need is just a smartphone application.” (L.187) In fact it is not Ming's problem not being able to work out the working prototype but because time is limited and we do not have enough material. But as a prototype it does not need to be fully functional. I told Ming that “faking” is totally acceptable. Ke also refer to his past experience how they faked the prototype in an important art festival competition and successfully won the time and chance to really made it in the exhibition. Ming immediately came out the idea of a prototype with someone faking the automatic association: “Ming: So, let’s have someone control the camera for us, it captures the picture every time the subject made some movements, and then we present the idea” (L190) Xid and Ming then exchange a little more on the meaningfulness level. “Xid: I think it is OK to think about practical application, if he(XM) insist.” “Ming: I think it is not very necessary to think about its objective, be it practical application or having fun. Because we express the idea through the same implementation” X started to agree with Ming's insist on the practical side, which at least means she can understand it is the practicality that is meaningful to Ming. Ming started to compromise and think that they can put aside the disagreement on the objective, and the meaningfulness behind, and just focus on the implementation.	vague Project meaningfulness - working out technical solution inactive participation referring to past experience agreeing meaningfulness and abandoning meaningfulness before more exchange on meaningfulness

This is a compromising attitude, weakening their meaningfulness and its influence on the project. in the post-interview, Ming opposed to this attitude. by saying: “Another lesson I learned from this workshop is to keep communicating with our group members. Otherwise, we will probably diverge into two directions very far before we notice. ” (see, A2.1) At the end of this episode, Ke encourage the group to make more constructive communication. Ke believes there is some way by which the student can reach mutual understanding. “Ke: we need practise, if you want him to understand you, then you need more than words. You need to draw, to show examples. It’s much easier. It’s a game of a group, we cannot let anyone do everything. I suggest you go out to see if there will be anything interesting. Even you don’t get anything, it’s still OK. For my own projects, I spent many days trying, and I get nothing. But finally I took one picture that is good(shaking head one)” (L.209)	compromising meaningfulness avoiding further exchange encourage communication encourage going out and trying out
Episode 5. Going outside (Line, 232 - 273)	
The Episode 5 documented the discussion right after their prototyping session outside in the campus. The whole conversation was in a fast pace, everyone was talking fast and continuously, giving response instantly. Everyone was excited and active. They know they have made something interesting and meaningful. What they discovered is a special effect when they shoot. They chose video mode inspired the accident in Episode 3, and they started to move the camera when the subject moves. For example, in one scenario Ming was rotating his skateboard he steps on. and in another scenario Ren was jumping while the cameras moves up and down as if it was imitating R’s movement, making a funny effect. Ke got excited the second he saw the effect. Although the effect was not that “powerful” as Ke used to suggest. But it did have a funny effect, which made Ke laugh and think of the name “you jump I jump”.	active participation Meaningfulness - fun

The consensus in the group is that this effect did make sense. it was result of Xid's original idea plus inspiration from the accident plus going out and trying out. In the final effect we did see a sense of “fun” therefore Xid successful realized her part of meaningfulness. At the same time the effect is very specific, so Ming was also quite excited about it. For Ke, the meaningfulness of powerful did not appear , but he just ignored that. So actually he did not think it is absolutely necessary to attach every meaningfulness, the fun and imagination of the effect itself evoke his other meaningfulness which is already enough to be very active and propose ideas - e.g. “servo” X present it in a very emotional way “Xid: these are not good enough. You can see me taking videos of them. This one. They are jumping and the camera is also jumping. Isn't it fun ??” (P256) while, Ren conclude the meaningfulness in the more logical way, trying to presenting it through reason, “Ren: we call it “fun with movie”, referring to the TV show “the big bang theory” There are two goals - 1. Let the subject control the picture, 2. we set three modes of fun movies. - three modes that we just saw. And just now, the enlargement effect that XM mentioned before is a kind of visual effect, can't be categorized into one of our goals, it's just a visual effect” (P 258) So when something can not be included in the reasoning, Ren considered as irrelevant. Nevertheless, for Ren it is still a “movie with fun”. So fun is an accepted meaningfulness to Ren.	agreed meaningfulness- fun missing meaningfulness not important Effect raising new meaningfulness minor divergent meaningfulness accepting meaningfulness - fun
Episode 6. The big fight (Line. 275-443)	
The last episode is a big fight on the naming. Xid wants to call in “You jump I jump” while Ren wants to call it “jumping video” The rationale for Xid is that “jumping video” is not fun, does not present her key consideration of “association”, But Ren did not seem to agree much on that meaningfulness. For her the naming should be easily understandable for users. “Xid: I think our product's focus is the association so “you jump, I jump” can highlight the association “ (L. 289) explicit meaningfulness for X	divergent meaningfulness not agreeing on meaningfulness meaningfulness- association

“Ren: but the users wouldn’t know the activity then” (L290) Ren: “Jumping video” is the visual effect (L.292) it is a clear sign that Ren did not think presenting the association is an important meaningfulness here. It is not as important as to make the name understandable. At the same time, Ren defends the name “Jumping Video” as the visual effect so that readers will immediately understand the content of the video. This straightforward attitude is again challenged by Xid. “Xid: but “jumping video” doesn’t sound catchy. will be disadvantaged when selling. Secondly “jumping video” doesn’t have a reason. Our point, the focus is the association, not that it can jump. “ (L.293) “Xid: then it makes you curious, so it is like a slogan” (L.297) For Xid, not being straightforward is on the contrary an advantage. It makes people curious about the content in the video. And people would understand the content after they see the video. This disagreement even upgrade to the level of judging the character of Ren “Xid: Renju is 又红又专 (holding a orthodox mindset) , she’s from Mechanical Engineering.” (L.301) “Xid: Therefore she is 又红又专 , I can’t persuade her, making me really annoying” (L.303) There was an emotional tension in the discussion and Xid could not stand the situation of not being understood. She blame this situation to the fact that Ren is from mechanical Engineering and holds a very strict orthodox on everything. R did hold a strong preference on rationalizing the project. She supports the meaningfulness using a very rationalized speech and tried to name the project in a clear and direct way. Another disagreement appears when Ke and Ming are arguing if they can use the software to represent the movement of the actual camera. Ming's argument is that the movement of a camera might change the habit of photographer, therefore he might not be so used to the new interaction. besides this point,	explicit stating meaningfulness arguing on the “Project” name meaningfulness influence name opposite meaningfulness to the same “project” idea emotion tension upgrading to personal character

Ming (together with R) also propose some other practical meaningfulness: e.g. calculating the relative speed, calculating the center of the video “Ming: Or it is contrasting to human nature.” (L 375) “Ming: I think there is another point that Joel mentioned, that taking video is a good way to recording the movement(speed) of the subject relative to the earth.” (L.382) “Ren: in fact, can it be like this, from technology pov. It can detect the center of the picture, so that if the photo is constructed unbalanced, the camera would move automatically to put the focus center to the real center” (L. 389) “Ren: can that people would understand better the rationale of the design , which is to capture the center of mass of the picture. Because normally people would ask why the camera move according to the movement of the subject. People wouldn’t understand what we try to express here. However, if we add the concept of center of mass, then the people standing here, the picture is not balanced, and then the camera would automatically adjust so that the center of mass is balanced. ” (L. 391) But Ke has the opposite opinion. He agrees on Xid's meaningfulness , that the association is important. and from his point of view, the two conflicts are two sides of one problem - what is the actual essence of the project. holding the same meaningfulness, Xid also do not think the challenge of Ming is a big problem, as the purpose is to challenge the current photographing and make new ways of photographing. Ke and Xid's meaningfulness can be indicated from the following statement. “Xid: I don’t think it’s a problem. There’s a lot of anti-instinct design.” “Xid: and this design . I really haven’t thought about its practical value. Or the practical details. Do you need to go that deep? Considering its value ” “Ke: OK, I think the point is to make people uncomfortable.” “Xid: exactly, I meant that, because it is a anti-human nature design” (L. 377-381)	different meaningfulness to the same “project” idea family meaningfulness meaningfulness practicality useful application not challenging status quo family meaningfulness meaningfulness association, new experience uncomfortable design(challenging the status quo)

K, in his final speech present very strong opinion of his meaningfulness (that aligns with the “association” meaningfulness)by introducing a new meaningfulness - not straightforward. If it is just the movement of the final effect, the audience will not be very persuasive of the effect, but if the they see the association, they will understand and they might be more interested. Ke wanted not only to design an association of designer, he wants the user to know about the design, why they should play this. And the user should know it from direct see the association. Ke also uses an example to explain this idea “Ke: I can give you an example, there is one video in the photodrama workshop. This guy tied the camera to a two meter long rope , and then rotate the rope horizontally, him being the center, camera facing him. And then he got a video, and he is in the middle of the picture, not moving much, but background rotating greatly. OK, now I only give you this video, you see the effect, but you don’t know at all what he want to express here, right? If you haven’t seen the other video shooting how he played with the camera (L.434)” The strong elaboration help the team to finally agree on the meaningfulness of “association”: “Ren: the association is really important, I now realise our project, the most important is the association between the subject, the photographer and the phone. But then not only these three, we also need to show to the audience. Let them know about the idea. So I believe the video and association should combine” They finally agree partially because Ke is mentor and his word has more authority. But also because he used several different examples to back up his opinion. And he was able to point out the key inconsistency in R’s argument. The meaningfulness was well presented and manage to make everyone back to a lined up situation. K was not a very strong mentor who gave ideas to participants, instead he tried to not interfere too much the project. But in the end of this episode, Ke presented a very strong opinion and persuasive attitude. His attitude is because he believe the argument has to end, as the team does not have enough time, and the team was heading towards the plain idea that overlook	explicit clarify meaningfulness providing supportive meaningfulness to connect referring to example agreeing on meaningfulness

the creative part - association , while Xid does not have enough persuasion power to bring it back.	good persuasion meaningfulness successfully influence “project” good persuasion

A3.2 Memo of [OF1-1] Interview Ming

Memo

Ming, male, engineering background, M1 student, group member of the movement-camera with Xid (designer) and Renjun in Mechanical Engineering design.

M is an engineering background student. His experience in a technology patent company had a lot of influence on him. In the company, he was surrounded by discussions on cutting edge technology with application potentials. Though there is no designer in the company, the discussion occasionally concerns human and society, which he believe is related to design. From one designer(Denqing) he once worked with, he learned that design is about the power in expression.

In this workshop, he proposed the first idea (lighting controlled by movement) to the group, but after one day brainstorming, the idea was discarded. Then Xid proposed another idea, which he failed to understand in the beginning. Especially in the interview, he used more the specific scenario and object to explain the design than the abstract concept of “association”, which Xid believe is the essence.

about himself

- I like better the patent company where people from different backgrounds gather and talk about interesting cutting-edge technologies than the research center doing only basic research.
- People in this company sometimes talk about the human side and application, therefore it is related to designerly thinking.
- (from what I learned from Denqing) Design is to be expressive, to have power in the expression.
- Denqing always brings the artistic sensibility, his design is magic and fantasy.

about the project

- My first impressive moment is when we went out and took pictures for inspiration, we were able to come up with good ideas
- Xid didn't specify the reason of her design, which made me confused. I got the idea when Ke Fang rephrase Xid's idea.
- My two group members have different design languages.

Some Excerpts and Memo

Ming: "Glasses, with projector, projected to retina, so that people can see the screen(voice not clear). Another one is a ball on hot water, they can control the movement of the ball by controlling the temperature of the water, kind of related to touch screen. "

These examples show that XM is very much interested in cutting-edge technology.

Ming: "combine two different things. He dares to really connect two very distant things and dig deep."

This combination is the process of creating a metaphor, it is used to make the "design" more expressive. So what XM mentioned here is consistent in Denqing's design philosophy It's a bit different from Xid's idea of "association"

Ming: "to control the configuration of the lens to change movement, which lead to the final idea. "

When XM explains their design, he used the very specific object "lens", while Xid focused on the "association" between movement and "parameter of the camera", a general description. What is important is the object itself than the "association" as a concept

Ming: " some augmented effect of certain action in the video, "

While Xid think the core of their design is the association, XM express the design in a more specific way. In his mind the randomness of artistic expression and the augmentation of movements are the core of design. XM didn't get the idea before Xid can demonstrate a specific scenario. The common language here is the "scenario". If Xid could propose an image, then XM could understand better

A3.3 Memo of [OF1-2] Interview Xid

Xid, female, design background, M1 student,

Summary of the interview:

Xid is a designer, who studied product design and knew about interaction design. She mentioned many times in the interview that design is a kind of association (e.g. between machine and human /

object and human / movement and reaction). For her, design is more abstract concept than artistic skills.

In this workshop, she believe her group was the most dynamic, because they had a lot of discussion, change of topic and heated discussion. The main dispute was around the core of their design - whether it is the association between movement and camera or the prototype implementation or the details of final video. Being the only designer in an interdisciplinary group, she felt her perspective was not agreed by the others, which pushed her to communicate.

Though the interdisciplinary environment was difficult, she seemed to enjoy and learn. On one hand, she believe workshop with more perspectives, e.g. Joel's physics perspective, is more open-minded, on the other hand, she realised being able to think in other's shoes and communicate in another "language" is a crucial part of design as well.

- Interaction design is an association between human and machine
- Design is a 理念(concept/philosophy), thinking of this made me anxious, because it is not very concrete or rigid skills, and can be quickly learned, therefore cannot secure my career.
- Workshops with only designers are narrow-minded, people like Joel can bring in new perspectives.
- The first idea - filling light for selfies - is not good, because using scenario is not realistic.
- The core of the second idea - movement controls camera - is the association between movement and camera, not the implementation or well organised details or the quality of the videos.
- We saw the same, experienced the same, but we understood differently.
- Understanding and communication is a big part of design as well, which I overlooked in past workshops where only designers attended.

Some Excerpts and Memo

Xid: "I think the this workshop had more practical implication and flexibility."

This flexibility is hard to understand without a context. But it was reflected later when she mentioned that design workshops with only designers are sometimes narrow-minded

Xid: In my undergraduate, my understanding of ID is : it is a relation between human and machine - how I acted and it reacted to my action, this association construct the interaction.

In her interview, she mentioned many times about the association. In her understanding, design is to associate something with another thing. For example, she thinks the core of her project in this workshop is the association between the movement of subject and the movement of the camera.

Xid: "For example, when Joel came to the workshop, and he talked about the relative motion of camera and subject, and the camera perspective of human motion, etc, this is something that I would never imagine as a designer or in a design workshop.

”
-

This perspective is from Joel's background, which added to her feeling of flexibility/mind-opening

Xid: " Because I think design itself is a 理念(concept/philosophy). Because I majored in design, so when I understood that, it made me anxious (about my career). Because I spent four years in my undergraduate, and I learned one 理念, a conceptual idea. You can't say it is complicated, because I believe it could be quickly nurtured under certain environment. The design mind/thinking... maybe.. is something like aesthetic taste, it can be developed if the environment is suitable. The artistic skills are more hardcore, and I don't have them. So it makes me feel anxious. Concept and ideas are abstract and can be easily gained. "

This answer does not fit the question, but the anxiety is very strong, almost the first reaction of the girl when she thought of the idea "design is a way of thinking/concept". it shows the confusion of "design" as a skill or just an idea/concept. It brought anxiety when designers try to identify themselves.

Xid: "Firstly, in the market, there is quite a lot of ways to fill the light in photo. And their effects are much better than direct filling light with really light directly to the face. There is many many ways. And then if it is stage lighting, they are very professional, they don't need this. So actually in the first place you can hardly build up the using scenario, can't find where you can use it. Secondly, this design, selfie equipment, should be portal, always for travel, so I think the application value is not big. Additionally, camera has its own flash, why do we need to fill light? I don't quite understand his point. I don't think it is a very good design. "

When she judge the design, she tend to judge it from user and market perspective. She try to find the using scenario.

Xid: "I think, because Ming, he personally hates post process. He just doesn't like to to post-proceed the photo, very persistent on that. It's true actually, a high quality photo need professional lighting

and angle. It's hard to do selfie with those. I can understand this point. So I think XM he personally has the need to use this . He is a loner, and he often went out without telling anyone. When he is alone doing a selfie and he doesn't have a good lighting, he must be very bothered."

While she thinks Ming is very self-centered when designing the product. She tend to think more from other scenario than herself using it

Xid:"Her talking is very organised, ideas very practical and logical, but these drives me crazy when talking to her. "

organised, practical and logical: these are normally good, but she can't stand it. She prefers ambiguity and openness

B. Project of "DNAish Food"

B1. Chris's background

The group was in the introduction section where everyone take turns to introduce their background. But it did not follow a strict one-by-one manner. As everyone has different background, the rest of the group needs to take a short period of time to absorb the information as one was introducing themselves. When the rest tried to comprehend, they interrupted the speaker and started to express their understanding of the issue at hand. The speaker then also responses to the questions. Chris explained his background as a scenography with the integral of sound, light, music, and art installation. This was however not immediately comprehended by the rest of the group. Matt, a biology researcher did not know about "scenography", and Juli, a science student, tried to relate it to one of a field she knows that seemed similar. The discussion then took a slight detour as Juli started to explain her knowledge of the interdisciplinary field between cognitive science and design.

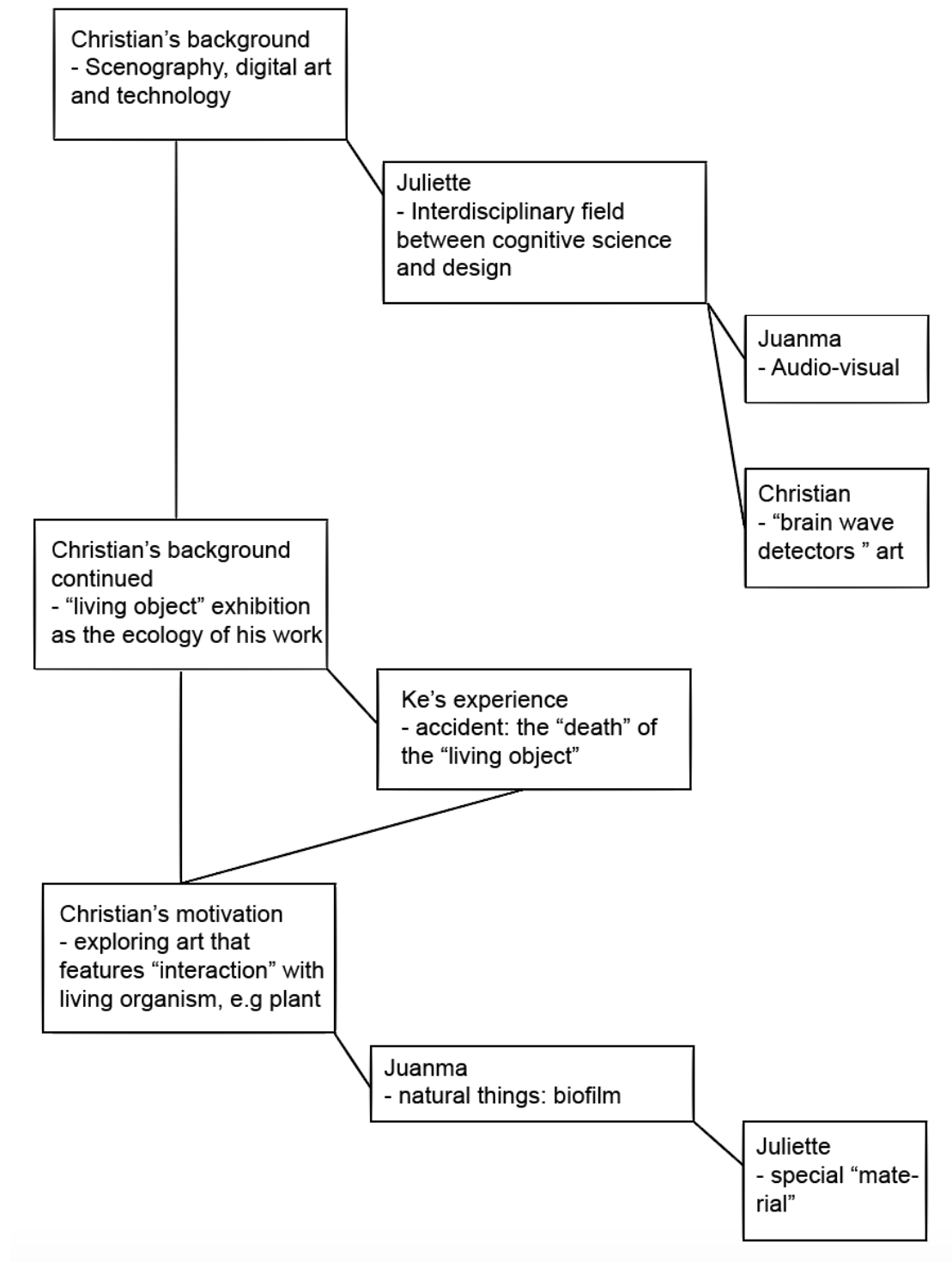
Comprehending others

Interrupting
Communicating to match understanding
Mutual communicating

Inadequate knowledge
Approaching from similar experience
detouring

<i>“you know there is a school, ... a field that connect cognitive science and design... it is (related to) visual art, sound design” (Juli)</i> Juli is a science student who has a great interest in the cognitive science. She was also quite interested in its application to more practical field, e.g. design. Her notion of the interdisciplinary field started a new round to comprehension among the group. Juanmat mentioned the term “audio-visual” to conclude what he understood for Juli’s description, and Chris recall some artist using brain wave detectors to make art, which seems related to Juli’s description. Juli approves everyone’s attribution and further elaborate that it is about using cognitive science and physics to compose design, art, and music. This small detour was part of Chris’s introduction with Juli’s contribution. In the end, Juli conclude the small detour by saying <i>“I just know this”</i>, which means she just recalled this interdisciplinary that is related to what she believe as relevant to Chris’s background and she thought it was worth to share. It means : <i>“I just know this (which I want to share with you guys)”</i>. Chris, who hadn’t finished his introduction then felt necessary to complement on his background, as it is not that easy to comprehend than a simple “biology”. He mentioned a coming exhibition in the next week called “living object”, in which artists use installation to explain what they believe as “living object”. He use this exhibition to explain the “ecology” where he works in. The group started to look at the exhibition website when Juanmat immediate found someone (an artist) who he’s heard of but forgot why. Before Chris even had the time to explain, Ke found the work of the artist to be one of his impressive experience. Ke started to explain his impressive experience: when the art work was exhibited in China, Ke once saw it was broken by one of the audience, which in turn made it accidentally more respective. One of his friend wrote a review about the accident which she believe adds more meaning to the art work’s origin meaning: The “death” of this object (the art work) reflect its “living” status. Again, Ke’s story was a small detour to Chris’s story. But again, it seems that Ke felt compulsory to share his story, which he believed relevant and worth sharing. The group did	interdisciplinary as connecting knowledge personal interest initiating sub-discussion mentioning familiar term recalling past experience grounding everyone’s understanding Recalling relevant past knowledge Wanting to share Needing to clarify Similar project in he “ecology” Impressive experience Adding meaning to original project Detouring

not feel interrupted, as they were reflecting on the accident and discuss on the notion of the “living object” – the name of the exhibition Chris mentioned. The topic of “living object” then drives the discussion into one of Chris’s motivation in the workshop. Chris was working closely with digital technology, at the same time he also wanted to collaborate with biological technology. For example, the topic of “living object” seemed to him a good topic to work on: <i>“I wonder if there is anyway to interact with living organisms, e.g. plants, say if we can genetic modify them and see the change in real time.”</i> Juanmat gave his answer. He believed even if there is any way to do that, it cannot be presented in the public but only existed in labs (due to GM regulations). But then he indicated there are much more ways to “play with” the natural living things. Juanmat made an example of “biofilm”, which is natural but at the same time has a lot of interesting features (e.g. appearance change according to different situations, e.g. temperature, etc.) that might fit in Chris’s definition of interaction. Juanmat’s notion of biofilm also reminded Matt of a specific plant that might has the same feature. When Juanmat and Matt discussed about the time it needs for plant and bacteria to have visible reaction, Chris implied that several months or even days is too long, which gave Juli another inspiration. She recalled that other than living things, there are also special “material” that could fit in Chris’s requirement, despite that Chris’s original demand was to look for “living organisms”. Juli was the founder of the “Material Club” in her university, and she often organized activities around the topic of material science and their application.	Wanting to share Regarding relevant Exhibiting motivation Looking for collaboration Proposing possible effect Regulation limits Proposing alternative solution Inspiring similar solution Time limits Inspiring solution Inspiration from personal interest

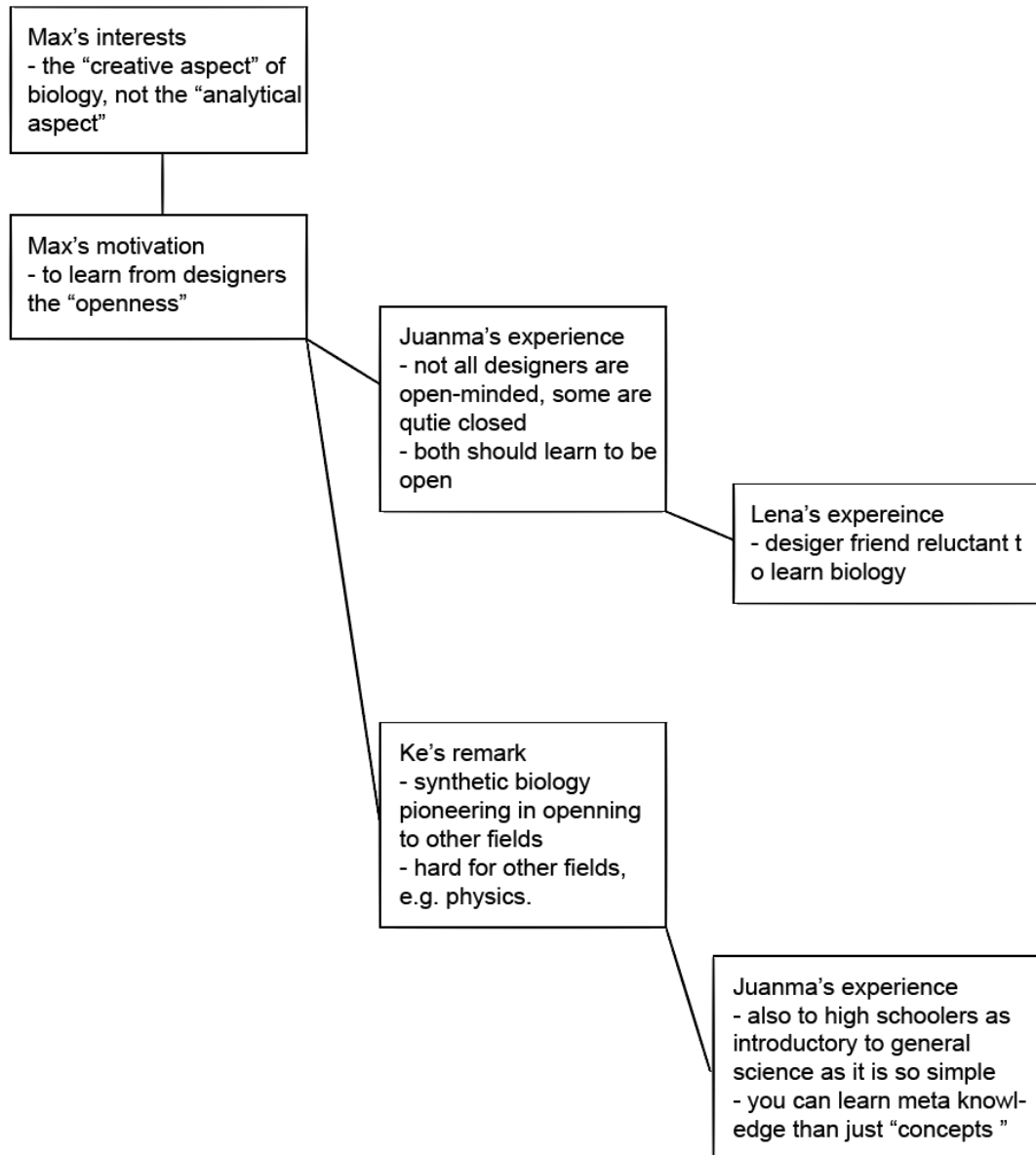


B2 Matt's motivation

Matt is a Ph.D student in biology. When he tried to explain his background and his interest in this workshop, he made an distinction from his research and what he believe as the	Explaining Motivation

traditional biology research. He mentioned several times, as he furthered his studies, he became interested in the “creative aspect” of biology science. The “creative aspect” means , in his own words : <i>”to have an idea and then implement it”</i> rather than to study <i>“what’s already there”</i>. This intention fits well the purpose of synthetic biology - the more engineer version of biology than science. Matt did not agree that the “creative aspect” means to the end of artistic purpose, but he suggested that scientists should learn from the designers and artists about the creativity and “openness”. Juanmat made a minor correction to Matt’s statement by saying that he believes it is not scientists should learn from designers about openness, but both should learn to be open to each other. Juanmat recall his working experience with designers, and he believes not all designers are open and some are even quite closed. Lina, a design student in the UK, agreed with Juanmat. When she first introduce biology to her designer peers, almost none of them is open to this subject. As for Lina, their rejection is a sign of not being open. After Matt explains his motivation, Ke complemented that he believe this “creative aspect” of biology, to make some things rather than just analyzing something, makes synthetic biology a pioneering field in terms of interdisciplinary collaboration: <i>“The physics, for example, is much harder to work with designers”</i>. Matt agrees, and mention that once the field is rigid in methods and ways of working, it loses its flexibility to be open, and that is why he is interested in synthetic biology and its creative aspect. Juanmat complement on this point from a similar but slightly different perspective. He mentioned using synthetic biology lessons to high schoolers as an introductory lesson to science in general. He had one experience with that in the previous summer, when he aggregate dozens of high schoolers in a student lab and teach them about synthetic biology. He also mention a NGO “bio-builder”, from whom he got the inspiration. To Juanmat, the synthetic biology brings in the openness from its simplicity.	Creative aspect To create not analyze Learning from other discipline Minor correction Recalling past experience Echoing experience Comparing physics with biology Research field becoming closed Similar different perspective Mentioning exemplary team

<i>“It is so simple, like a black box, you have the genes and then what see what you do and get the result, sometimes dangerous, yes, but very simple.”</i> This simplicity, to Juanmat is a good feature that allows high schoolers and outsiders to open a door to the science world. He believe it is not only the laws, facts, results – but the meta knowledge that makes science: how scientist work, how to write science, how to talk like a scientist, etc. <i>“When we learn, we do not only learn concepts, but also the meta knowledges, like in school, the kids does not only learn about the specific rules like how to sit, but also the meta knowledge.”</i>	Simple for general understanding An open tool Meta knowledge as essential Comparing meta knowledge to schools



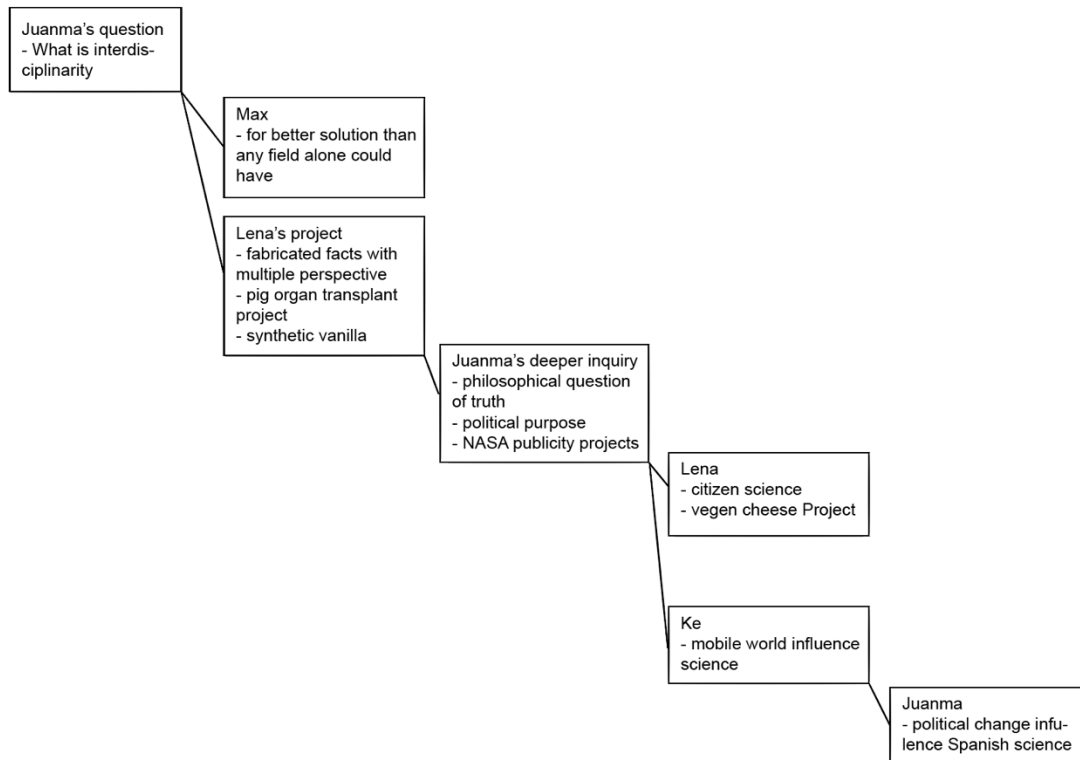
B3 What's interdisciplinarity

Juanmat invites the group, before entering the science part, to join a group discussion on the concept of "interdisciplinarity", as he believe although the concept is now more and more popular, different people might have different perspectives on it. He believes it is necessary for the group to communicate and ground the basic understanding of it: <i>"when a word is so much used in so many context, it might lose its meaning, so what is interdisciplinarity to you?"</i>	Discussing on interdisciplinarity Multiple meaning and no meaning

Matt believes the purpose of interdisciplinarity is to reach a better solution: <i>"It might generate a solution much better than any field alone could have."</i> Then Lina put forward her purpose by quoting Bruno Latour's "thingness theory", which she read in a paper and became fond of it. She explained that the fact is not only about the fabrication of the scientists but also the others who participate in the social word. Everyone has their own perspective on the fact and they together fabricated the collective reality. The social reality, and the real reality, is not confined to one perspective. It then need interdisciplinary to happen in the beginning so that different views can be taken in when the "fact" are being fabricated. The saying of "fabrication of fact" is inspired from her read of Bruno Latour, but it speaks about her motivation in interdisciplinarity, which is letting everyone takes their perspectives in the process of knowledge generating and technology creation and find the "intersection". Matt seemed a bit confused about the "fabrication of facts" : <i>"So does that mean the fact is a better fact? A more valuable one?" "so this intersection is what is real? Objective?"</i> If you are a trained scientist, you might get confused upon the notion of "fabricated fact" with "manifold perspective", as we often hear "fact is fact" and why should scientific fact be fabricated in ways beyond the scientific methods? When Lina sensed this confusion, she gave an example of her own third year project to explain. Lina's project got inspired by a group of scientists who are working on grow human organs on pigs for the use of transplant. More specifically, they are finding ways to use CRISPR(a gene editing tool) to get rid of the virus so that pig organs are safe for transplanting to humans. But as a designer, Lina's eye on the facts turns to other perspectives: e.g. she asks who is going to manage the transplant and where will it be implemented. When she found out the government is in charge of managing transplanting, she realized the conflicts between the private company who funded the research and the government might need a solution. She also wants to know how in reality it will be implemented in the society: People might view pig very differently; the conflict between society use and nature living, the hospital scenario where the patient will need to choose from wait for natural human organ transplant or pig organ transplant; etc. She is concerned with these issues and believe her perspective can be involved in the science	Better solution with multiple disciplines Referring to social theories Allowing more perspective Fabricating facts needs more perspective Finding intersection Feeling confused Emphasizing realness and objectivity Using past example to clarify the "fabricating facts" Designer looking at A real science project A alternative perspective Social reality Sensing conflict Implement science in reality is an issue Social controversies

research, or, as she quotes Bruno Latour, in the “fabrication of facts.” The pig example raised Juanmat’s interest, and he reminded that in some areas, pigs are somewhat unsacred, and in some other areas, pigs are religious. Growing human organs on pig might create political and religious issues. Matt starts to understand this. He thought about the insulin grown in pig that is used in diabetes, which is not a big problem to scientists. For him, the science world seems to accept those issues quite fast. But he also understand what Lina meant by the different perspective of the issue. <i>“It makes sense to ask those questions”</i> Another example Lina made is a synthetic vanilla made by a group of scientist. They claim it to be closer to natural hence healthier, as the vanilla now we use are basically chemicals. But then Haagen-Dazs says they will not use it as it is genetically modified. And the consumers also does not want to buy it. The conflicts is between the scientists’ fact, which is a healthier and probably cheaper vanilla, and the another fact, which is GM not acceptable to Haagen-Dazs or the consumer. Lina says she does not think the research is a waste, but she suggest a collective perspective and a better communication once the science research is actually implemented in society. Juanmat views this topic with a deeper perspective. <i>“I think we can see this in a more philosophical way, the epistemology aspect – that is one person enough to know the truth?”</i> Juanmat thinks we need people of different perspectives to know the truth – the philosophical truth. He mentioned an old Asian story in which several blind people wants to know about elephant. With one touching the leg, one touching the tail, one touching the nose and one touching the ear, no one actually get a correct answer what an elephant is like. The story aligns with his quote of a Spanish philosopher, that the only knowledge that is close to true knowledge is common knowledge. Juanmat then point out another side of the issue, the political side. He believed that some of NASA’s project is not only for science but also for public communication, e.g. looking for water on Mars. He thinks NASA need this publicity projects to	Involving different perspective Reminding social norms Raising political aspect Starting to understand Bringing in relevant but slight different example Admitting designers’ perspective has meaning Giving another example Natural vs GM Scientist fact vs social fact Promoting better communication Science implementation in society Delving into deeper thoughts Philosophy thinking Referring to tales Quoting philosopher Raising political perspective Bringing NASA’s example

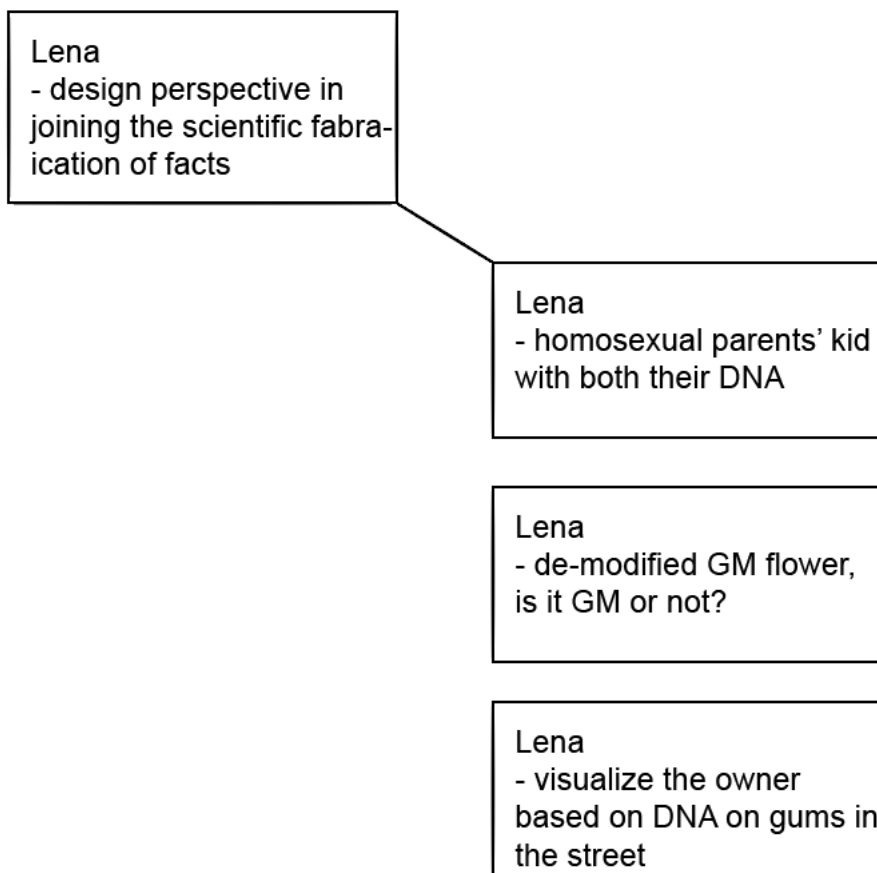
get attention and funding, and on the other side the public also needs science. <i>“We now live in democracy and the public needs to know that science is important, and also science needs the public to understand it, to think about science, so it is a political issue.”</i> Juanmat’s input throw the group into further discussion on the “deep” question. Matt and Ke believe the specifying of science makes science more and more alienated to the common life, while on the contrary it affect daily life to a large degree. Lina mention the growing popularity of citizen science makes scientists understand that it is important as it frames the science problems in a way that common people can understand and participate. She gave example of the Vegen cheese Project, which helps the public to understand better about a GM product that frees animals’ lives or suffering. <i>“The framing is helpful for scientists to better communicate their project.”</i> <i>“When you have applications that actually touches people’s life”,</i> that is the conclusion from Matt, who in the end totally understood what Lina meant. In response to Juanmat’s point of mutual influence between science and the society, Ke agreed by giving the example of mobile device. He believe the mobile world we live in now implicitly shapes how we think and see, shapes the question we ask and the method with which we look for an answer. Science is also shaped by the society. Juanmat mentioned another experience to echo Ke’s point. Because of the political economy of Spanish government takes, many Spanish scientists go away and those who stay take a different approach than the way they do in the US or China. The science is in the society and is influenced by the social political status.	Promoting the democratic value of science communication Provoking discussion Science alienated with life Science should relate to life Framing science in public’s language Recalling project example Concluding other’s point Showing agreement Responding statement with example Further echoing statement with another real life example



B4 Lina's design examples

Lina is presenting a few examples before the narrative workshop. She straightens out the purpose for the workshop, which is to generate conversations and allow design perspective in the scientific “fabrication of facts” (refer to D1 fieldnote 3). She has to make the science people understand the importance of this purpose before she can deliver the workshop. Therefore her presentation is essential. She chose to directly showcase the design projects to present the “design perspective”. These examples are not random, you can see she purposely chose design projects related to life science so that the biologists feel more attached to their life. The first project is about the utilization of a bio-degradable material – mycelium: low-technique but quite strong in terms of rigidity and fire-proof. The exploration of such materials, not necessarily high-tech but useful is one of the promising direction for designers. Another similar project features the use of natto – a Japanese traditional ferment food, as natural material to detect humidity.	Making examples Expressing purpose Design perspective in fabricating facts Presenting to make people understood Showcasing projects Relating to the other discipline Usable bio-material Ferment food

The exploration of material is one thread of the design science collaboration story. Then Lina introduces another thread which intends to bring design narrative to science. For example, one of the design project speculates a technology to help homosexual parents to have children with both their genes, which is inspired by a true science. The designer not only speculates the technology, she also create the life story for a couple, what is the families' life like. She creates a film with computer graphics, which moves Lina a lot. It is touching because Lina can actually see the technology being used and feel the reality of the science. Another designer makes a genetic modified flower which reverse a GM flower to its original status. It creates a paradox of whether it is GM, as at one hand it is made with GM technology, but at the other hand it de-modify its artificial features to return to its origins. The paradox further provoke the question of what GM is and how should we see and deal with it. In the third project, the designers collect gums on the street and visualize their owners based on the DNA on the gums. The visualization is on one hand a technology, but on the other a question on the security and the rights of such information we randomly give away everywhere. For Lina, These are the stories illustrate her purpose in this narrative workshop. These speculative design, or design fictions, help to relate the technology to people, to life and to the socio-cultural context of where it is being or will be used. It helps to imagine a future where technology is being considered with a design perspective. For Lina, they either asks a question, or frame the technology to a context so that it is easier for people to comprehend with their daily life experience. And in this workshop, she wants everyone to make these kinds of narratives so that different perspectives can clash and hopefully we can find a way to learn from each other and integrate.	Design narrative into science Speculating sci-fi with design perspective Designers making movies Audience Feeling touched Feeling the reality of science Creating controversy GM discussion Raise awareness of bio-info Using example projects Relating technology to life Future with design perspective Framing technology to a context Making narrative to engage different perspective

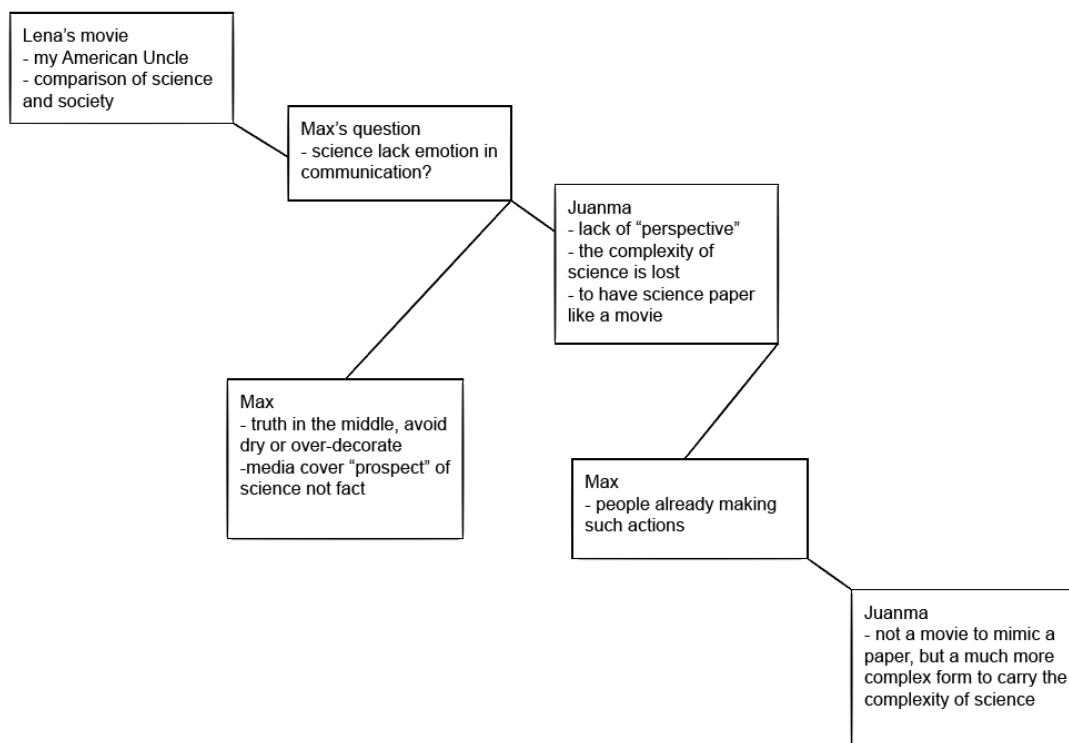


B5 Does Science Communication Need Emotion

Just before Lina starts the workshop, she share with the group a movie she found very inspiring. It is a movie called My American Uncle(Mon oncle d'Amérique) written by a French scientist Henri Laborit. To Lina, the movie constantly compare mice experiments to societal relationship which explains the science, especially neuro science in a way that is related to the society. <i>“The meaning behind the movie is “big” – concerning the science of emotion and how it affect our inner organs, which compares to the social stories which gave pains to people through hierarchy relationships.”</i> The movie is a perfect example which makes science and society relatable to each other and presented in a way that easily understandable and with emotions.	Sharing movie of relevant concept Connecting science to society Discussing meaning of movie Social relationship and pain Relation between science and society

The movie raised the interest of Matt: <i>“are you saying when science communicate to the public, they are lacking some sort of emotional thing and just talk about facts?”</i> Juanmat made a small change to Matt’s statement. He believe there is a lack of “perspective”. As a scientist, he understand science is complex, but the way science is presented to the public often appear to be so simple and even boring. <i>“We say that it is the DNA is like this, and that it makes the protein.. and forms Ebola, we say it in a way as if it is that simple, but it is not.”</i> While Juanmat implies that scientific facts should not be presented in a brief and “dry” way, Matt pointed out his concern of overdoing it. What troubles Matt is that he often observe media articles that reports a prospect of a scientific finding, instead of reporting the scientific fact. “When we find a molecular that can better recognize cancer, the media says cure for cancer discovered”. Therefore he believe the truth is neither in the “dry” fact, nor in the over-decorated media-report manner. But what is at the core of the problem? Juanmat point to the problem of research paper, which often takes a fixed structure of literature, method, experiment, results, etc., which is not how science is actually implemented. <i>“Science at lab is very messy, always in the cloud, we make a mistake, we throw away result...”</i> The core of the problem, is how do we extract that? How do we present it? Should the outside know about it? It is a yes for Juanmat. He believes the way we present our research should include incidence like daily dialogue like “Hey Rebecca, nice discovery!”. Science as a whole should be present, not just the results, in a hollow way. <i>“I imagine to have science paper as movies, so that people can really emphasize on what is really research in science”</i> The “movie” statement soon catches Matt’s eye, and he pointed out that some people is already taking actions: <i>“some nature movie about science process”</i>. But Juanmat doesn’t think this approach is what he meant. He also knows of a	Science communication Needing emotion Minor correcting Boring presentation Dry expression Opposite concern Middle ground reality Referring to real lab experience Comparing reality with presentation Presentation of a complex problem Valuing daily dialogue Presenting the wholeness Movie as new media for science presentation Referring to news reading

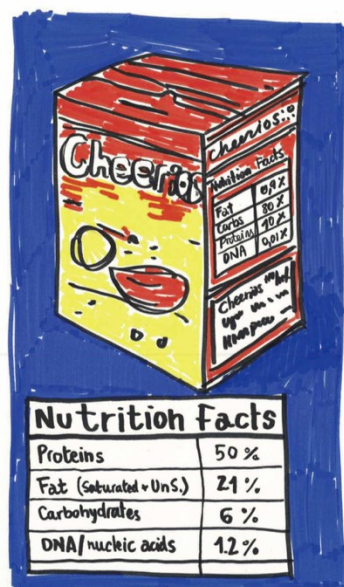
journal which accepts a video instead of a paper. But that's NOT what he meant. He doesn't want a video to present a paper, he wants a form of publication in which it carries the complexity of science research. <i>"There will be part where there is nothing, there will be part that is contradictory. It is complex and I think movie is a right form for this. It is not like 'hi, I am Juanmat, I am the researcher and I am going to explain to you about the protein that .. this kind of videos.'"</i>	Opposing the misunderstanding Carrying the wholeness and complexity making example with jokes



B6 Labelling DNA content

Juanmat was the first to present his story. He wanted to think of something new, something outside bio-engineering with which he is so familiar. <i>"I want to get rid of all the preconception I have."</i> He focus on what he calls the <i>"social impact of scientific vocabulary"</i>, and particularly the concept of DNA. He imagined a daily scenario of a future kitchen where a family is having their breakfast. While everything else seems normal, there is one thing strange: nutritional fact table on the "Cheerios" (Cereal food brand) marks the DNA content.	Outside of comfort zone Trying new things Getting rid of preconception Society and science Abnormal reality

Juanmat drew the “Cheerios” out, and everyone laughed when they noticed the DNA content on the label: how funny! Normally, DNA is not put on the nutritional fact table, as it does not count as nutrition. But Juanmat rationalized this as a mark of the “naturalness” of the food: the more DNA it has, the more natural the food is, since it has more organic compound and less chemical ones.



Name: JUANMA GARCÍA

Topic/reference/technology of interest
Social impact of scientific vocabulary / pop science

- Who(Person/Animal/Bacteria)/When (Immediate or future?)/Where does this scenario take place?
in everyday's life, people, families,

Questions to consider:
 - What happens in your scenario?
 - What is your attitude towards synbio?
 - If you are stuck - think of the details. What will the technology look like a physical form? How will it interact with the person interacting with the technology?

In this scenario, people learn and take part of the scientific vocabulary, using metaphors in their daily life. DNA is advertised in food and a higher expectations is taken.
 > Cheerios packages with DNA content.
 > Science vocab that evolve over time... (oh, that's so 80's.) Science meta-culture.
 > how maybe not modified or natural bacteria or organisms get to change people's life.
> purine ingestion <

CO-LAB
 コ・ラボ

Feeling strange and funny

Rationalizing abnormality
 Science concept meaning making

So DNA becomes as good as a kind of nutrition like protein! But soon this speculation was challenged by Pratek, a participant with biology background. Pratek pointed out that DNA is phosphoric acid, which “*isn't cool*” for people’s health. This argument soon evoked a round of discussion on the chemical component of DNA and their nutritional value. The “phosphoric acid” argument was debunked by Juanmat by saying that the “phosphoric acid” is not free in the DNA, but instead confined in the chain as part of a larger chemical: “*It is like saying coca cola has carbohydrates because it has CO2 (which is not correct because CO2 is just a part of the carbohydrates and not free to move away from the main part).*” But Caline, a participant with both biology and design background, argued that another component of DNA, the “purine” might add kidney’s burden as she once learned in a medical course. Her arguments seems more evidential to the other participants, but Juanmat argues that the burden also exists when one has too much protein. The biological discussion continues as Matt wants to calculate the exact number of the DNA content.

Entering question from a different perspective
 Evoking discussion of a different perspective

Discussing on science

Comparing a daily example

Referring to past knowledge

The biological discussion was not expected in Juanmat's original idea. His intention was about the *"social impact of scientific vocabulary"*. But When he made the claim that the DNA is seen as a kind of nutrition, as a sign of healthier food, people started the above discussion.

When the biological discussion ends, Juanmat continues his story. This future kitchen has a green window full of algae and another window with red bacteria that is good for health. The mother was talking about engineering and fitness, while the son told mom that these topics were so "80s" and not fashionable any more, science vocabulary is the current new faction !

When Juanmat finished his future scenarios, he also speculated how his speculation could be realized at the moment by implementing "science activism" actions. He proposed that the group can maybe go to the street and put on stickers (like "containing DNA") to the food. He got this inspiration from the artist group who made fake corporate advertisement that ironically reflects their indifferent attitude towards the environment. The artist and activists puts those fake advertisement in the light box of bus station during the COP21 conference in Paris as if there were real advertisement by the companies(This happens in Paris around the time the workshops took place, so everyone has real life experience with it).



"Ah, that's nice!" The group hailed to this proposition, and started to discuss the fake advertisement activism which many

Unexpected different perspective

Raising discussion

Daily expression with Science vocabulary

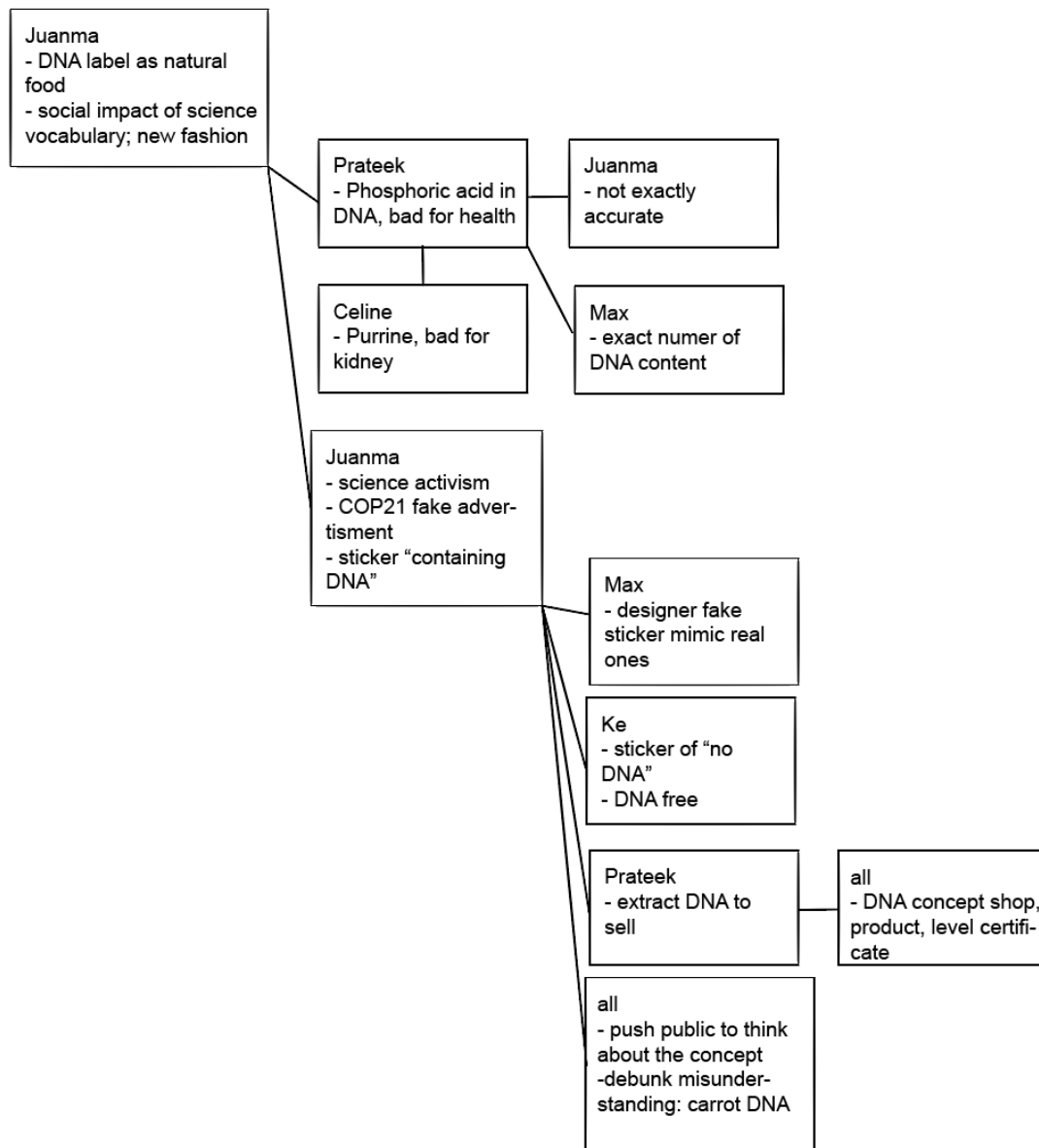
Future to current

Performing street art

Inspired from on-going street art

Reference of daily acquittance

of them knew or even witnessed. Inspired by this, Matt proposed that designers can design the stickers to mimic real stickers on food, just as the artist mimic the advertisement. Ke proposed to design not only “containing DNA” sticker, but also “no DNA at all” stickers, which immediately echoed by Pratek: “Yes, <i>like DNA free</i>” “Yeah, yeah”. Creating a science activism ignites everyone’s imagination. We saw ideas after ideas coming up. Pratek propose it is possible to actually extract the DNA with alcohol or soap, (he knows it as he has done it in his biology experiments) and sell it as a kind of food addition. This idea soon inspired more ideas to make DNA concept shop, DNA products, and DNA level certificate etc. The rationale of this is that all this activism can push people to think more about the science concept, so that people can really understand the science behind instead of just following false understanding, one of which Juanmat knew, is about a report saying carrot has a lot of DNA and eat carrot will make people yellow as the DNA starts to translate inside human. The yellow effect is true, but it is not how DNA works.	Receiving accomplishment Resembling past reference An opposite proposition Igniting passion Outburst of ideas Inspired from past experience Extending narrative Presenting rationale



C. Project of “Chrom-air attack”

C1 Interaction Design – Reinventing the Rules

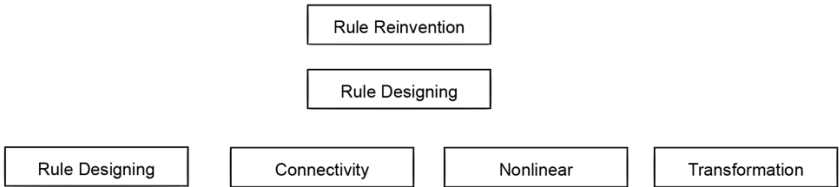
Denqing gave his lecture on interaction design in the first day to all the colab students. This lecture served as a “starter” for all the students to have a taste of “interaction design. Since

Lecturing
Preparing the students
Interdisciplinary field

most of the students participating in the workshop were science background, Denqing believes it is important to have a lecture and explain what design and interaction design means to him, in contrast to what normally design means. The Interaction design concerns designing interactions between human and human as well as between human and object, especially computers. Most of the interaction design in current design schools deals with design issue with human computer interaction. But Denqing didn't start with any orthodoxically textbook definition of "interaction design", he starts with his own understanding as a design practitioner, with several features of interaction design he summarizes, namely "designing rules", "interaction", "connectivity", "non-linear narration" and "transformation". The first feature he summarizes is that interaction design is essentially designing rules, instead of designing the end product. This is the first and most frequently mentioned feature in his following mentoring. To Denqing, the rule is more essential than the object, appearance, and in many cases rules can generate end product, therefore designing rules lead to designing final product, but is inherently a higher level. He gave very simple example to illustrate what "rule" means. "Imagine you cannot find one of the "knight" when you want to play chess, what would you do?" Denqing believes most people will just find a replacement, e.g. an eraser. In this case the specific object doesn't matter, the eraser will function as a "knight" in the chessboard, exactly as if it were a "knight". Hence the "rule" defines the functionality, the playfulness, the logic, and the game, not the appearance or material or anything specific in making the physical "knight". "The traditional design deal with the physical part, but that is not the focus of interaction design" , as Denqing put it. Denqing believes, and as he presented to the whole workshop, that interaction designers play with rules. One example he gave is a font design project where no specific fonts were designed. In fact, the designer works out a rule for generating new fonts from old fonts. The metaphor they use is DNA. The designers define the rule with which two fonts can gave birth to a new third font by exchanging their "font DNA". The new	Clarifying deep meaning Interdisciplinary Starting with example Summarizing features of interdisciplinary design Making rules Daily life Example Abstracting concepts Interdisciplinary project Relevant to audience

created font then has both features of its parent fonts but is different from any of them. The designers created new fonts not by traditional font design method, but by inventing a new rule. Denqing seemed every excited in explaining this point, he again uses one of his favorite design work to back up this argument. The “rule-designing” perspective mentioned here constantly appear as the workshop unfold. And we will come back later to this point and argue this is an most essential feature among all his five features. Then, Denqing takes his time explaining the second feature of “interaction”. Denqing gave three examples how Designers play with “interactions”. The first example is his own work – “collider”, exhibited in the Ars Electronica 2014. The installation is a door locked by a magnetic lock and will open instantly when people run into it without deceleration. It is intentionally designed for people to believe it will open in the last moment. This interaction is quite risky and provocative. The second example is a fashion design that will protect people from the smoke. The original design reacts to smoke and makes alert, and then Denqing help to improve it into an active interaction – the clothes will emit an anti-smoke gas which smells and only smells bad to people who are smoking. The upgraded interaction works like a weapon to fight. The third example is a furniture design for hospital. The original design was an ipad associated with chair so that people can play and interact when they are waiting. Denqing also helps to adapt it into a more sensitizing interaction design to help very painful patient to be more prioritized in the line. The design is a line of chairs, more uncomfortable to the front and more comfortable to the rear. The painful patient doesn’t care if it is uncomfortable because they already feel painful. They will choose the uncomfortable chair at the front and then get treated faster. The interaction is implicit but very subtle and creative. As we can see here, although Denqing was talking about interaction, it can still be interpreted as a way to design rules – rules of interacting, between human and object, and between human and human through designed objects. Denqing’s emphasize is still on the “rule” side of the interaction, not the object. As we will see later, this emphasis appears again in later elaboration of the following features.	Exemplary/impressive projects Using metaphor “Weapon” Consist focus on rules – cluster of meaning Similar different

The next feature “connectivity refer to when we design the interaction and rules in this digital world, we can design and as designers, we are interested in designing collective and connected activity. “Telegraden” is an example where people can attend to their plant online, and the community of virtue garden actually makes a collective garden and generative collective gardening activity, such as helping other’s to attend to their plants. The next feature “non-linear narration ”refers to designs that changes the traditional way of narration. E.g. in one of his design “sound theatre”, the physical space of theatre is thrown away and audience thrown onto the stage and they will experience in zero distance with the actors which completely change the narrative as in traditional theatre. The final feature, transformation, means designers can transform the perceived to another form in a meaningful way. The example he gives is an artificial intelligence photobooth. Instead of making picture, the photobooth will sense the user and makes a poem to describe the user’s face. The transformation emphasize the mediating role of design. The photobooth is one the mediating tool from one sensation to another. The five features that seem to be in parallel has, as I read, an internal logic, and from his uses of examples, we can find an important implicit feature. We need to point out this feature to better understand Denqing’s perspective and hence to understand his influence to the following workshops The implicit feature is the intention to challenge the status quo, to make radical change, to create new things, especially new rules, to resist plain application in conventional ways and to crave for creativity. There is a strong intention to challenge the status quo as he elaborate his definition of design. The first feature he used is the design rules rather than the final object, but to me, what he believes as designing rules is more like to reinvent the rules.” “he is not satisfied with the status quo, he constantly challenges it with new rules and new metaphors. E.g. “connectivity is not only virtual, but also physical”	Connected activity Exemplary projects Past experience / project Meaning introducing to workshop Challenging the status quo Attitude as Connecting social meaning

“designing rules, not result” “interaction not necessarily digital” Denqing doesn’t seem to be satisfied with taking the status quo for granted. For example, the last point of “interaction not necessarily digital” referring to the chair example challenges the normal interaction design paradigm. Besides the very creative idea, the design secretly remove the element of digital device, leaving only the chairs. But the concept, and the functionality of the design is complete and rich, leaving no room for a digital device. He provocatively asks, why interaction must be digital. To him, interaction when fully established doesn’t need a digital tool, which challenges normal understanding of interaction design - to design digital interaction tools. Denqing describe this lack as a plus. The creative nature of the design and the rule breaking spirit much overweight the status quo. When we review his other examples, the photobooth, the collider, the anti-smoke, we can sense in all these example a hint of creative intention to resist against plain and straight-forward application. Therefore, the basic feature units are “interaction ” ”connectivity” ”nonlinear narration” ”transformation” that describe the entry and perspective that a designer might take as entering tools. And the “rule designing” is a higher level feature which is the emphasis on all the above features. The rule to interact, to establish rule.... Denqing seems to present a stance that Interaction designer should know that their ultimate focus is the rules of these different entry point. And the final implicit feature is that the designing should to some degree to be creative and challenging the status quo, to have the power to say that I am making a new and radical change to the existing rules, to reinvent the rules  To understand the design presented here, along with the examples Denqing used is essential in understanding is the following episodes. There is relative little interaction between Denqing and the students, except a very brief Q&A section.	Provoking the status quo Less is more Spirit of rule breaking Connecting social meaning Meaning relevant and introduced to working Project

Although the interaction is brief, the presentation did make an important role. Student when working on their own project.

C2. The Metaphor of Weapon

The mysterious and unusual metaphor of “weapon” is key to understanding this workshop. Actually in the official booklet documenting this workshop (see data set[CL]) we actually name his workshop “Colab Bioweapon”. The “weapon” was purposely introduced to the workshop.



This episode gives details on questions like: How the metaphor, as the key concept in this workshop, was introduced to participants; What the purpose for the weapon metaphor was; What was its function in this workshop; And how it was related to the other elements, i.e. interaction design and synthetic biology.

The metaphor of “weapon” was an invention of Denqing. It never appeared in any discussion in the first Co-lab, so it was the first time co-lab workshop and Denqing’s weapon metaphor combined. Denqing requires every group will need to design a “weapon” that fights against environmental problems as their project. The group will also need incorporate the biology and

“Weapon” as connecting concept

On purpose pedagogical design

Weapon as metaphor

Purpose of pedagogical tool

Designing pedagogical tool

Delivering requirement
Conceptual resemble

design principle, knowledge or techniques they had learnt from the previous lectures. In a post interview, Denqing explained his rationale for introducing the weapon concept. He described the “weapon” as an object that do not solve any problem that either designers or scientists are familiar with. As Denqing observes in his past teaching practices, normally students are quite comfortable rushing into problem solving with their knowledge at hand. The pre-knowledge narrows the scope through which they will see the problem. The narrowed perspective is often to which their knowledge can immediately apply, but the we need to stay open to the complexity of the problem and its plausible alternative solution. A “weapon” is first of all an alienating tool, which forces the participants to take into consideration an unfamiliar problem or a new perspective. After all, one rarely thinks about designing one weapon in their peaceful life. As Denqing furthers his rationale, he consider the “weapon” as a neutralizer. The “weapon”, as an alien object, functions as a “hammer”(as Daqing put it) to break both designers and scientists’ structured knowledge. The “weapon” then forces them to forget where they come from, and to deconstruct their knowledge and reuse them in ways neither of them is comfortable. But thanks to this discomfort, it leaves space for both perspectives to enter. The “weapon” makes sure both of the disciplines have voice as no one now can be the expert. It then neutralizes the situation and invite both perspectives to enter with an equal standing point. With the rationale above, one can better understand why this seemingly distant metaphor makes sense in this interdisciplinary workshop. When Denqing explains to Juanmat and Ke about this rationale before the workshop, it didn’t take long for the two to agree with the idea. All of the organizers at least believe it is an idea worth trying. After the workshop, when organizers gather to reflect on the result, they agree that the weapon did prove its usefulness. It was not perfect as expect, but it did in some way help the student to open their eyes . With the above rationale, Denqing prepared a lecture specifically to introduce the metaphor. In this workshop, Denqing used extensive examples to illustrate how “weapon”	Project fitting the weapon metaphor Alienating familiar context Prevent rushing into familiar realm Pre-knowledge limiting perspective Alienating tool Rare scenario Breaking knowledge structure Leaving space for more perspective Equal voice Quick agreement Acknowledging experiment Partial useful Lecturing

can inspire new directions and how “weapon” can be related to interaction design and biology. Here we will pick up some of the essential points he made in the lecture. To see more details, please refer to (<i>Documents [CL2-1] colab-weapon(Denqing)</i>) 1. The Five elements – conflicts in environmental issue, weapon, synthetic biology, interaction design, science fiction <table border="1" data-bbox="161 607 983 949"> <tr> <th colspan="2">Five elements of the workshop requirement</th></tr> <tr> <td>The Target Problem</td><td>Conflicts in Environmental Issues</td></tr> <tr> <td>The Solution/Speculation Metaphor</td><td>Weapon</td></tr> <tr> <td>Key knowledge of Reference</td><td>Synthetic Biology</td></tr> <tr> <td>Key knowledge of Reference</td><td>Interaction Design</td></tr> <tr> <td>Presentation Format</td><td>Science Fiction</td></tr> </table> Denqing started the workshop by making a five dimension requirement of the workshop, which framed the project that students will complete within roughly two days. The first element is the target problem for the project. We chose the environmental issues to be the key target problem. Students will need to come up with a project that response to an environmental issue. Choosing Environmental as the target was Denqing's idea, as he believe it was difficult to randomly come up with a weapon design. The final solution or speculation will need to be a “weapon” design. For example, the “anti-smoke” clothes (see episode 1 of this ethnography) purposely emit gas that smells bad to people smoking is a kind of “weapon”. Apparently, in this sense, the “weapon” is not used for its literal meaning but its metaphoric meaning. Synthetic biology and interaction design are the two disciplines of knowledge to refer to. The project will need to apply knowledge in both areas. This principle was flexible, and later more of less changed to applying interaction design and science in general (synthetic biology preferred). For example, some group starts with Synthetic biology technique in the beginning but soon found out that only synthetic biology is not enough. They turned to general biology and chemistry	Five elements of the workshop requirement		The Target Problem	Conflicts in Environmental Issues	The Solution/Speculation Metaphor	Weapon	Key knowledge of Reference	Synthetic Biology	Key knowledge of Reference	Interaction Design	Presentation Format	Science Fiction	Making examples Requirement Framing project Giving target problem Avoiding random project Mentioned example Metaphoric meaning Incorporating knowledge Forcing interdisciplinarity Flexible requirement Starting perspective
Five elements of the workshop requirement													
The Target Problem	Conflicts in Environmental Issues												
The Solution/Speculation Metaphor	Weapon												
Key knowledge of Reference	Synthetic Biology												
Key knowledge of Reference	Interaction Design												
Presentation Format	Science Fiction												

knowledge to look for more appropriate solutions. All the organizers were OK with that flexibility as the purpose is to encourage exchange between science and design, between different communities, not necessarily a specific group. The last element of Science Fiction means that the students will need to come up with a scientific fiction where the "weapon" will be used or presented. It requires the students to give context to their final solution. Moreover, as the context has to be a "science fiction", it implicitly encourages more creative and imaginative ideas. To understand the five elements is easy, however to understand the internal logic and relationship among the elements in the design process is hard. - Which elements should I start with? - Are all elements absolutely necessary? - Is there an order of the elements when brainstorming? - Which elements should I emphasize while compromising or even omitting others? Denqing immediately tried to address these potential confusion by giving what he believed to be an ideal designing process with the different elements: "You can start with whatever interests you the most, do not follow the order we give you, but focus on finding the connection between the elements. In the end, we recommend you integrate everything into an coherent story... You should try to start as broad as possible, but end with a more specific angle that is most creative and appealing"(Denqing explaining the logic of the elements in the design process) In this sense, we can understand that Denqing's five elements is more flexible than hard requirement. They more serves as an inspiration than as a must-do. However, it doesn't mean Denqing emphasize nothing but a random process, there is at least two emphasis in the above excerpt as well as in his later mentor: 1. They should find way to connect the different elements. 2. They should try hard to make it "creative" and "appealing". And we will see in the later episodes what exactly these means to him. 2. Weapon Examples	Expanding knowledge Flexibility to general science Presenting approach Situating context Implying creativity Entangling element Generating project with elements Raising questions Prioritizing elements Clarifying confusion Example of ideal process Starting with interests Emphasizing connection Integrating elements Starting broad Generating creative Elements as inspiration Connecting is key

In clarifying the five elements, especially the “connection” of the five elements. Denqing illustrate a few weapon examples:

- **Time bomb: the rule, not the impact**

The first weapon example is the “time bomb”. “What is unique about time bomb?” Denqing believes the uniqueness is not about how impactful the bomb is, or what material it is made of, but about the link between time and destroying. The time bomb Again, Denqing emphasized on the rule, not the physical impact of the bomb.

Emphasizing the rule



原型分析 stereotype analyze



- **Fuse: weapon and biology**

In the next example, Denqing demonstrated how weapon can be related to biological knowledge. Denqing compared the fuse to the neurotransmission, and encourage student to look for more similar connections.

Connecting biology and design

Information flow through neurons

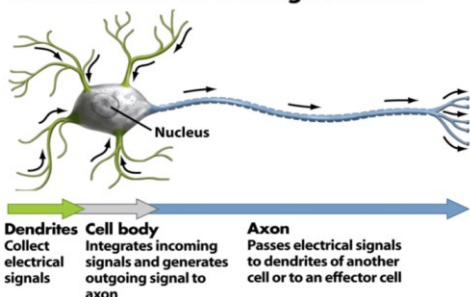


Figure 43.20 Biological Sciences, 2/e
© 2005 Pearson Prentice Hall, Inc.

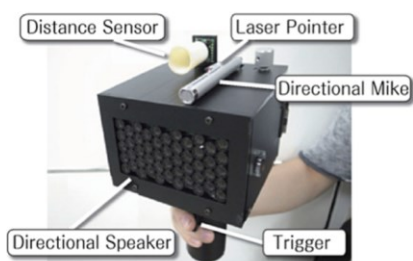
Neurotransmission



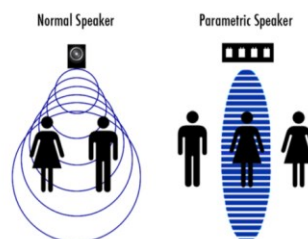
Fuze

- **Sniper and Parametric Speaker: Weapon and Interaction Design**

In the last example, Denqing compared the sniper to an interaction art work. The art named “parametric speaker” explored the possibility of directional listening and directional speaking in public spaces with a special speaker. In a flexible comparison, Denqing believes the speaker is like a sniper, and one might get some inspiration from this metaphor.



parametric speaker



In exemplifying the weapon metaphor, we can understand Denqing did not come up with the weapon idea from zero. He himself had been exploring some simple prototypes already. In his examples, rules and connections are still the focus. To Denqing, one should focus what rules make the weapon special –the “time”, or the “transmission”, or the “direction.” These rules can connect the different elements of the workshop. To conclude his points, Daqing presented an ideal model:

Is there anything related to time in the environment conflict? Is there anything related to time in the rule of weapon? In the Synthetic Biology, or in the interaction design? Try to connect the dots with the rule and get inspired

Using examples

Prototype developing

Focusing on main social meaning

Connecting the dots as creating

The metaphor of weapon is a key concept in this workshop, largely attributed to Denqing and his consideration on interdisciplinary learning. There is no similar concept in the first Co-lab workshop before. It serves more than a simple metaphor, but a potential tool to break the pre-knowledge and reconnect the disciplines as well as the wicked problem. It is an invention. In the next episode, we will unveil how this strategy actually works in reality by close participant observing the project of the “Chrom-Air Attack”.	Pedagogical tool Using an invention

C3. The start of the idea

The group work started from right after Denqing’s lecture on weapon (4pm, Monday). They were encouraged to go out and start their brainstorming in a beautiful sunny garden.	Going out



The group starts in a very divergent manner, they propose idea after idea. It seems they listened to Denqing's advice to think as broad as possible in the beginning. Some of the ideas were direct solutions to an environmental problem, while some others seemed to emerge from the "weapon" metaphor.

Although the ideas were emerging fast, I observed some features of the discussion that showed a biased focus towards science. The imbalance is partially because the group was formed mostly by science students. For example, whenever an idea was proposed, there seemed to appear a serious discussion on the feasibility of the proposition. As new ideas were always immature and vulnerable, critiques on technique feasibility often stopped the group from going deep. The first round of topic sharing had a similarity. It follows a pattern. A direct observation of a problem and applying a direct technology. At this stage, the design side of the narrative is weak.

Although Denqing's did advise the student to be divergent, but not at the price of only discussing superficially without discovering the potential of the ideas. The strategy the group uses was more like: "proposing-criticizing on the feasibility-proposing new idea". Therefore the connection between science and design wasn't fully established as they do not have the time to dig deep enough.

The discussion lasted for around one hour, and generated surprisingly 7 ideas, presented shortly after.

Starting divergent

Providing direct solution

Biased focus towards science

Group Formation imbalance
Feasibility concern

Vulnerable ideas

Divergent but superficial
Facing difficulties

Easy to give up

Many ideas emerging

Converging

With some discussion after, the group finally converged to one project, which they find both feasible and adequately interesting: a home decoration, e.g. a wall painting, that can change its color according to different environmental conditions, e.g. air pollution. The color change is the result of certain biological process, e.g bacteria reacting to the environmental change. This idea became the initial prototype to their final proposition. The idea was challenged by Denqing in the next day when he presented the bubble idea.	

C4. Denqing's Bubble

A critical turning point of their project appeared in a discussion with Denqing in the beginning of the third day. Denqing liked their idea of color changing wall painting, but proposed an alternative object to carry the feature. Before explaining his idea, Denqing first demonstrated an artistic music video of the song "heartbeats" by José González. In the video, tens of hundreds of colorful balls were bouncing freely in every corner of a city. The enormous bright color balls bouncing across the streets in a calm city is quite mind-blowing with its outstanding visual imagination. (See the picture below and the music video for reference).	Turing point Similar different case Visualizing Project Impressive project



Colorful and imaginative

Inspired by this video, Denqing provocatively asked what if the color-changing object is not static, what if it is not a single object, what if it does not only stay at home, what if it is moving freely, what if it is like, as in the video, a group of objects that

Speculating based on the project

can present a stronger visual imagination, what if it is something that appears far beyond the home scenario but reaches to a city scale?

Following these questions, Denqing proposed that a possibility that the object can be the bubbles that we often see kids playing in city square. The bubbles can change its color according to different conditions, and they can also fly to different corners of the city. The bubbles will be directly seen by people in public space.



There is no answer which idea is better, everyone will have their own opinion. But Denqing introduced a few things that were missing in the original proposition.

First is a strong visual presentation. The colorful balls are amazingly beautiful to see in the music video. Although the group gave their idea of a wall painting, they did not specify which one or its visual effect. Denqing did not just present his idea, he used a very strong visual reference when trying to sell his idea. This strong visual presentation changed people's perception when they think of the idea.

The second is a sense of playfulness and the "feeling of artistic and romantic". In addition to the apparent practicality of indexing environment, the bubble is symbol of playing and romantic feeling. This romantic feeling was mentioned frequently afterward in the group discussion.

The third is a degree of "strangeness". The music video is unique. People do not normally see this scene in their life. This strangeness is a challenge of status quo: why not a lively colorful city? Certainly this strangeness will be challenged with

Trying to connect to the current project
Changing scale

Changing balls to bubbles

Speculating scenario

Bringing in aesthetic value

Visualized presenting

Sense of playfulness

Feeling romantic

Feeling of uniqueness

practical issues, but that is not the first concern of Denqing. He believes this strangeness is a plus. The group did question the feasibility and practical issue about this idea, but they never questioned the three value above. In fact, the group in their later discussion often refer to these values to defend the meaningfulness of the proposition.	Accepting alternative meaningfulness

C5. Scientific and Romantic

How was Denqing's idea received by the group members? Did they like the idea? Did they understand the idea exactly as Denqing's idea or did they adapt and develop the idea? The last part of the episode presented how the group received and developed their project after Denqing's inspiration. In general, the group accepted Denqing's idea and believed his idea makes sense especially in terms of artistic presentation. But the group kept their concerns on the feasibility issue and a lot of the discussion was about this direction. But occasionally, when the group focus too much on the detail and get stuck, they are able to get back to the artistic part and found their way out taking this perspective. The group's interaction slightly changed from "totally scientific" to a mixed status of both "keeping scientific" and "accepting romantic". Although Denqing had very vividly presented the idea, the group didn't give up their strong intention to think about feasibility. The first few rounds of discussion were focused on this directions. For example, Four key issues emerges as the group proceed: 1. What material and form should the bubble take ? 2. How to change the color without introducing more pollution to the environment? 3. Following the second issue, how to "kill" the bubble before it falls? 4. How to build the machine that makes the bubble and where to install it? The group presented a very high level of scientific and engineering knowledge and skill, with which they almost solved all the problems .	Keeping both meaningfulness Working on material and form Concerning second polluting

For example, the group investigated different possibilities of bubble forms: liquid bubble, half liquid bubble (liquid when made, become solid when exposed to air), solid state material that can float (e.g like snow) . They carefully discussed on how bio-sensor or other forms of color changing method can embed in the different bubble. In discussing on how to kill the bubble before landing, the group investigated different methods: such as pressure, temperature, liquid mechanics, oxidation, etc. In making the installation, they investigated the idea of a floating island over the city controlled by light pressure. Very probably, these detailed discussions would never happen if not for the interdisciplinary workshop: rarely scientists would think of making bubbles that can change color in the open air, and kill themselves before landing– the whole story doesn't make sense for the sake of science alone; nor designers with similar ideas would seriously discuss the scientific detail: "why should they ?" they may probably question the necessity of that detail in such an imaginary design. The discussion can be a scientific research topic, for fun; and it can also inspire the design to advance, as we will see in the next parts. There are also time when the group get stuck in the detail, and then question the whole idea. But instead of turning away as they did in their early discussion, the group will pick up the artistic and romantic side to complete the narrative and reconfirm it is meaningful. There is one small incidence took place in this stage which is noticeable: when Xiaoding (the designer) ask if the sensor can be something in the city, e.g. oil container. The answer was quickly given by one of the biology student, that sensor is a receptor, a receptor reacting to a specific trigger, with all the scientific explanation followed. He was not considering why Xiaoding asked the question in the first place. But if we look back the question, why does Xiaoding ask about something in the city, why she give specific example like an oil container. As a designer, instinct tells me that the girl has something to say about the example, which is not very much about science, but about the functionality of the object itself. Might be that oil container has some special meaning that is worth exploring.	Solving problems Discussing on different solution Project only happening in interdisciplinary workshop Re-making sense New meaning For both science and design More perspective to turn to asking alternative function quick answering scientific meaning reason for original question alternative meaning

The idea was not even developed, but just as a “baby proposition”. this “baby proposition” just take the form of one very easily neglectable sentence, and its full meaning that might exist in the designer’ mind but soon disappearing in the driving meaningfulness of the discussion happening at the moment. We will never know what the implication of the girl, which might has the potential to redirect the project, to nurture new creativity. It is not a pity, these small incidence happens all the time, and it is impossible to get every implication spoken out and developed, if that is to happen, there is not time, and the project will go nowhere. But this small incidence is unnoticeable, that some ideas are easily overwhelmed by the driving meaningfulness.	small project proposition neglected project oppressed meaning driving meaningfulness potential new direction regular neglecting under developed project proposition

C6. The science fiction

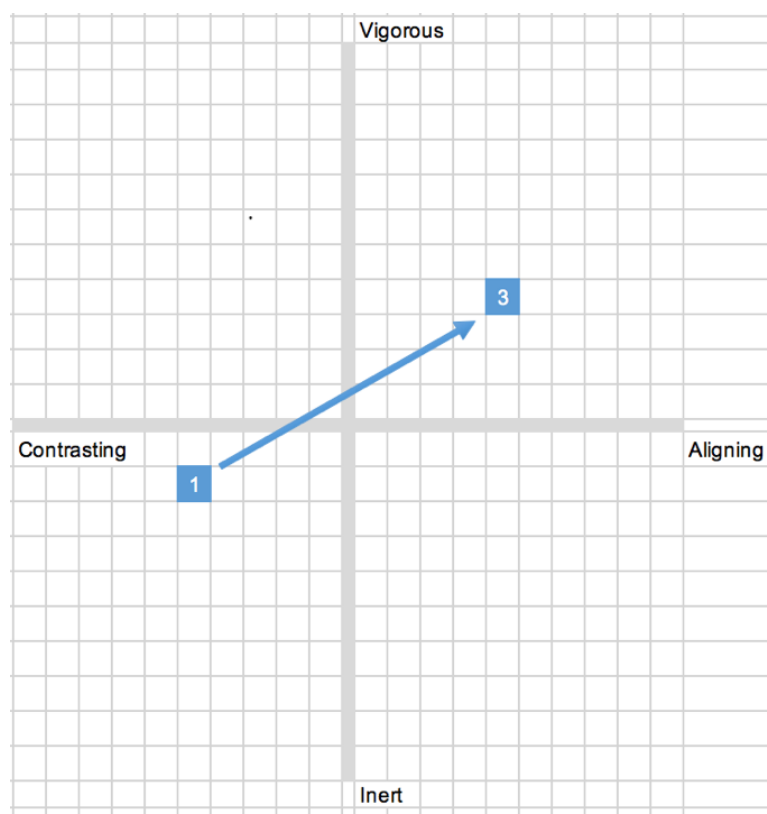
With a few rounds of discussion of both scientific part and the romantic feeling, the group developed a certain degree of agreement and confidence in the project. Their passion was however ignited by the final science fiction. When discussing on the project, the designer Xiaoding kept on mentioning scenarios. She was more comfortable to put the object into a scenario or a story then discussion on the object of its own. For example, when the other members of the group was focusing on the specific object that can change color, they mentioned the air itself can change color. But Runda oppose to that idea saying that a room of red color air would make it scary to breathe. This scenario soon caught Xiaoding’s attention. She immediately added: “So we are looking at a scenario where there will be some human interaction right?” While the others were discussing on the object, Xiaoding was thinking about the scenario, whether there will be people and whether they will interact in it. This intention lead to her proposal of a scenario very different from the previous discussion. She proposed a dark future where the entire world were polluted. And the only color they	Achieving confidence Emphasizing scenario Focusing on scenarios Make up stories Focusing on the object Opposing function Noticing scenario Raising awareness of scenario Scenario with human interaction Proposing new scenario

see in the air was the red alert of bubble. This dark future scenario soon catches everyone's attention. Runda soon developed a continued version of the story, based on this scenario: Still in the dark future, everywhere is polluted by pathogens, everyone has to wear a mask and people were hunting for space with safe color. The more colorful the bubble is, the more detrimental the air will be. In the end, they finally found a part where the bubbles are colorless. Seeing the colorless bubble was like seeing oasis in dessert. People take off their mask and breath the clean air. The sci-fi ignite the group, everyone looks very happy with the story. "OK", That's it" They were all applauding for the story. The story was so attractive that people started to add more to it. "Bitterly romantic! " Jinrong describe the sci-fi with the following: "it looks like romantic, but in fact it is an irony, the more color there is, the more bacteria there will be. Scientific knowledge was also added to the final scenario: how the bubble will be degradable, easy to explode, without pollution. The group did not give up their many scientific details, but they started to attach the science part to the sci-fi story. Xiaoding adds also another question of how human can interact with it, which leads to an idea of a protection suit that will change color. People can then visualize there degree of being polluted. Xu believes this idea was not as "romantic" as the bubble, but do agree with the others that it can be included as a "side product", the bubble being the most attractive, while others more practical with the same technology. The Bitterly Romantic began to be a commonly accepted description of their final product along side with their very detailed technique to realize the bubble.	Impressive scenario Completing scenario Aha moment Achieving agreement Summative description Keeping the science part Attaching science to scenario Adding human interaction perspective Reaching side product

D. Co-Meaningfulness Trajectory Examples

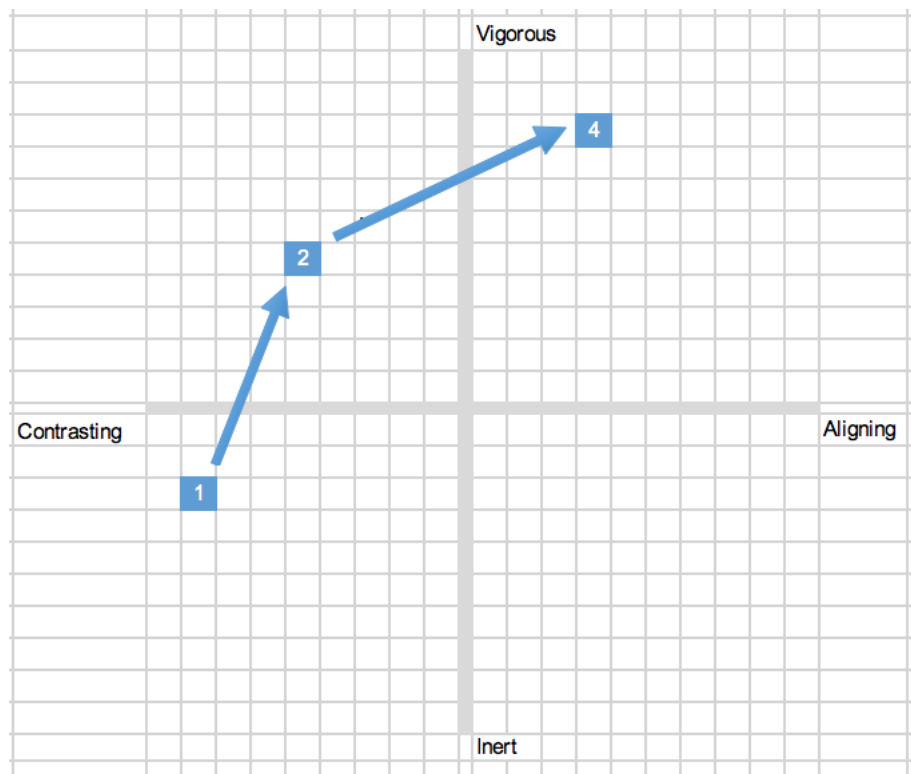
D1. Co-Meaningfulness Trajectory Example of B2

			1.Max' creative aspect	2.Juanma's double openness	3. synthetic biology as the connecting experience
P/M intensity					
1	Evoking	present	[-] little presentation of the specific "Project" of the creative aspect	[+] Lena's giving examples	[+] Juanma synbio school experience
2		understand			
4	Applying	present			[+] using analog to present meaning
5		understand	[+] Ke understand and giving conter exampe		
7	Prioritizing	present			
M/M Coherence					
3	Evoking	agree			
6	Applying	agree	[-] Juanma not agreeing on the design "creative"		[+] similar meaning of synbio field
8	Prioritizing	agree			



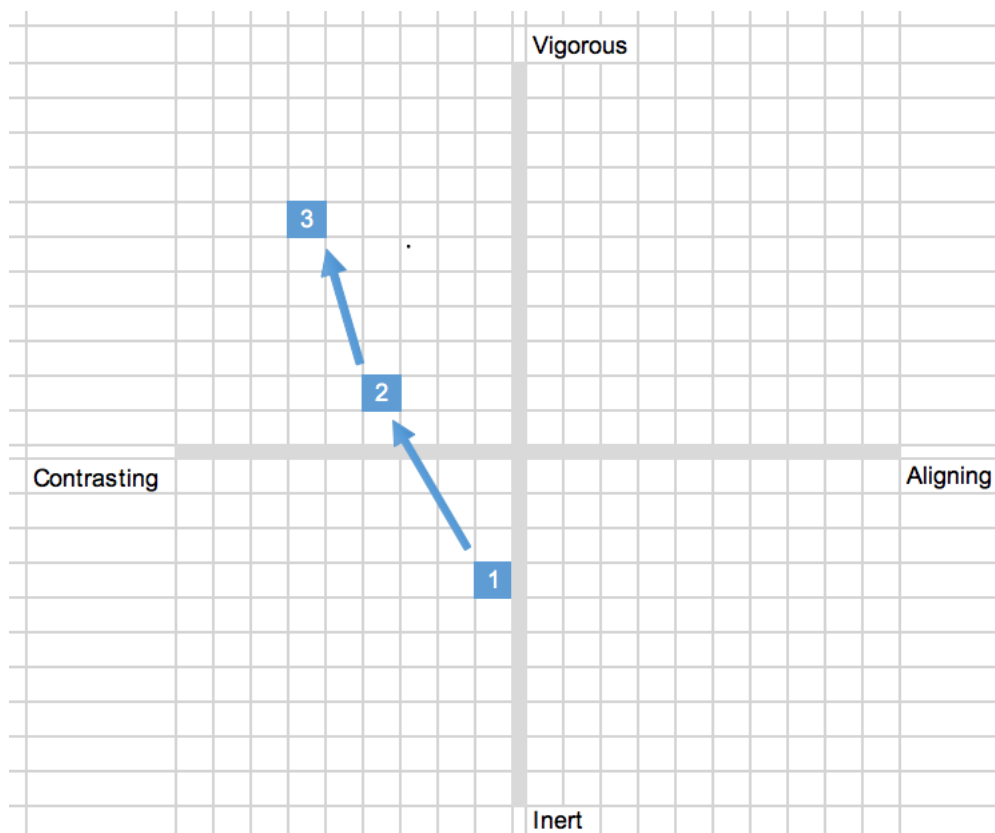
D2. Co-Meaningfulness Trajectory Example of B3

			1. Lena's fabricated fact from Bruno Labour	2. Lena's "Project"	3. more Lena's Project	4. Juanma's deeper perspective
P/M intensity						
1	Evoking	present	[-] too much theory explaining	[+] detailed project description	[+] detailed project	[+] NASA example
2		understand	[-] theory not understood			
4	Applying	present		[+] meaning elaborated	[+] meaning elaborated	
5		understand	[-] meaning not understood			
7	Prioritizing	present		[+] Lena's own Project		[+] Juanma's political interests
M/M Coherence						
3	Evoking	agree		[+] Juanma completing		
6	Applying	agree		[+] Max making sense		
8	Prioritizing	agree	[-] concerned with more perspective equals "better" facts	[-] Max proposing alternative scientific meaning		[+] Max agree and expressing similar meaning



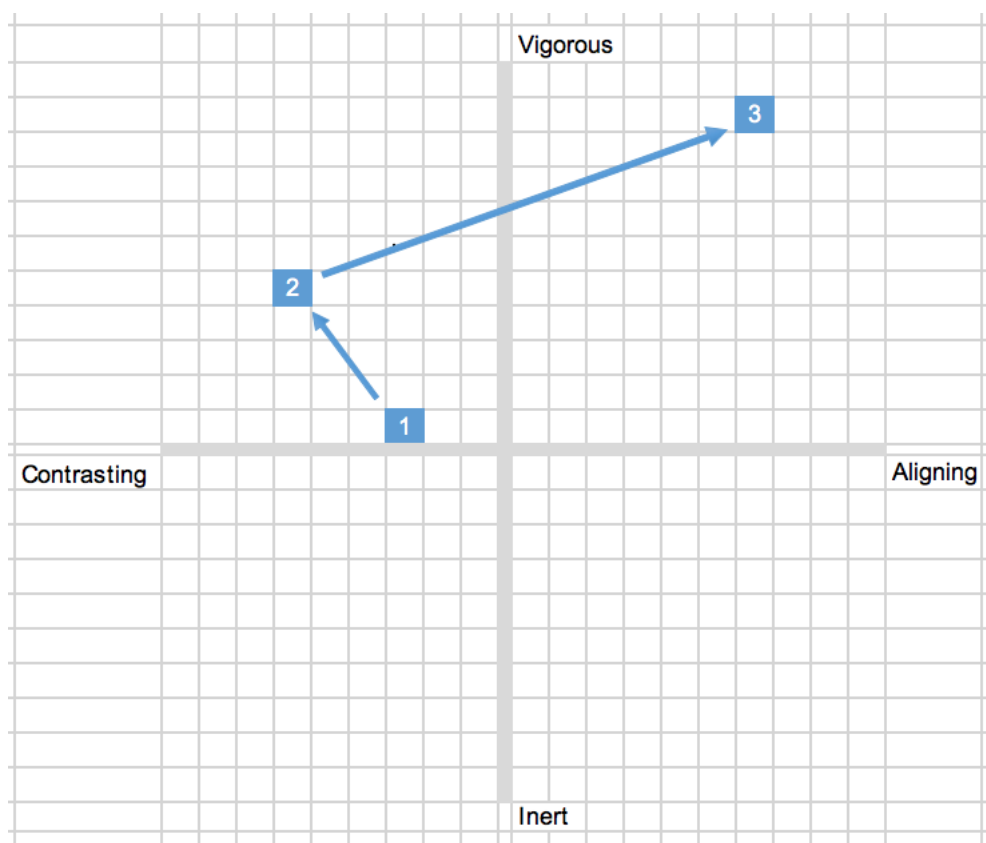
D3. Co-Meaningfulness Trajectory Example of B5

			1. science communication needs emotion	2. Max concerning overdo	3. Juanma talking about sicenec publication
P/M intensity					
1	Evoking	present	[+] movie presenting	[+] present with past experience	[+] daily life example
2		understand	[-] Max focus on emotion		[-] not understanding the relevance
4	Applying	present			[+] more detailed meaning explanation
5		understand	[-] not understanding the meaning	[-] Juanma omiting the meaning of Max	
7	Prioritizing	present	[+] personal interest		
M/M Coherence					
3	Evoking	agree			[-] evoking irrelevant example
6	Applying	agree	[-] Juanma: science needs more perspective not emotion		
8	Prioritizing	agree		[-] different prioritizing	[-] not sign of agreeing



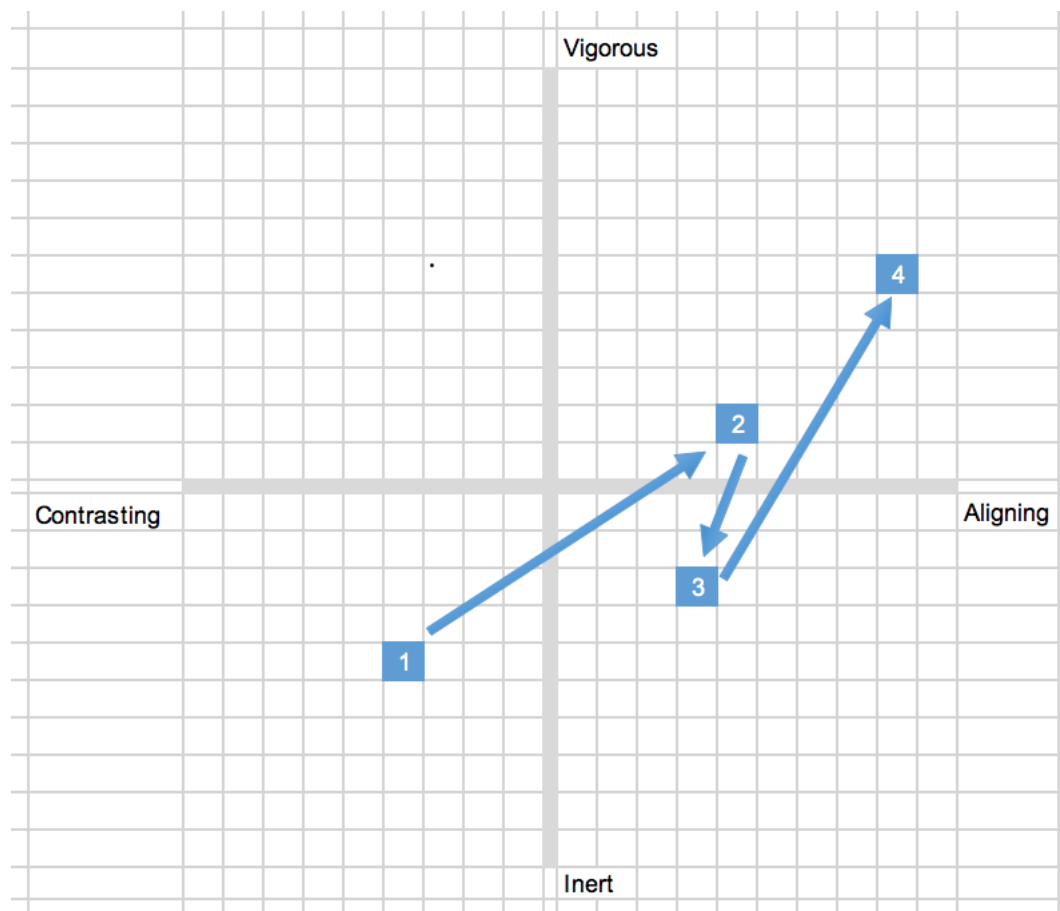
D4. Co-Meaningfulness Trajectory Example of B6

			1. Juanma's narrative and the biological fact	2. biological facts debate	3. science activism
P/M intensity					
1	Evoking	present	[+] narrative presented in story with drawing	[+] more facts brought into the debate	[+] COP 21 daily news
2		understand		[+] all very understandable	[+] all know the daily news well
4	Applying	present			
5		understand	[-] meaning not understood		[+] the meaning of COP 21 well understood
7	Prioritizing	present	[+] Juanma liking his inspiration		
M/M Coherence					
3	Evoking	agree		[-] not agreeing on the facts	
6	Applying	agree			[+] all recognize the activism, with similar meaning
8	Prioritizing	agree	[-] story or science fact ?	[-] not agreeing on story of science fact	[+] science communication with activism is useful and cool



D5. Co-Meaningfulness Trajectory Example of C3-6

			the start of the idea	Danqing's bubble	science and romantic	the science fiction
P/M intensity						
1	Evoking	present		[++] visualize impressive project		[+] scenario built and presented
2		understand	[-] science facts not understandable to designer			
4	Applying	present	[-] meaning not explained			[+] connecting summary "bitter romantic"
5		understand		[+] the artistic value understood	[+] understand both scientific and romantic	
7	Prioritizing	present			[-] oppressed designers' prioritized meaning - interaction scenario	
M/M Coherence						
3	Evoking	agree	[-] not agree on the feasibility			[+] applauding for the science fiction
6	Applying	agree		[+] recognizing the aesthetic value		[+] agreeing on the bitter romantic
8	Prioritizing	agree	[-] different prioritizing		[-] scenario vs technical and romantic	[+] final science fiction to connect romantic and human scenario



BIBLIOGRAPHY

- Archer-Kath, J., Johnson, D. W., & Johnson, R. T. (1994). Individual versus group feedback in cooperative groups. *The Journal of Social Psychology, 134*(5), 681–694.
- Aronson, E., Blaney, N., Stephan, C., Sikes, J., & Snapp, M. (1978). *The jigsaw classroom*. Beverly Hills. Ca: Sage.
- Baker, M. J. (2015). Collaboration in collaborative learning. *Interaction Studies, 16*(3), 451–473.
- Bhattacharjee, A. (2012). *Social science research: Principles, methods, and practices*.
- Blumer, H. (1986). *Symbolic interactionism: Perspective and method*. Univ of California Press.
- Blumer, H., Thomas, W. I., Znaniecki, F., & Bain, R. (1949). *An Appraisal of Thomas and Znaniecki's The Polish Peasant in Europe and America*. Social Science Research Council.
- Boden, M. A. (1999). What is interdisciplinarity. *Interdisciplinarity and the Organisation of Knowledge in Europe, 13–23*.
- Bryant, A. (2017). *Grounded theory and grounded theorizing: Pragmatism in research practice*. Oxford University Press.
- Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis*. sage.

- Cohen, E. G., & Lotan, R. A. (2014). *Designing groupwork: Strategies for the heterogeneous classroom third edition*. Teachers College Press.
- Cole, M., & Engeström, Y. (1993). A cultural-historical approach to distributed cognition. *Distributed Cognitions: Psychological and Educational Considerations*, 1–46.
- Denzin, N. K., & Lincoln, Y. S. (2011). *The Sage handbook of qualitative research*. sage.
- Deutsch, M. (1949). A theory of co-operation and competition. *Human Relations*, 2(2), 129–152.
- Engeström, Y. (1987). *Learning by Expanding: An Activity Theoretical Approach to Developmental Research*. Helsinki: Orienta-Konsultit Oy.
- Engeström, Y. (2009). The future of activity theory: A rough draft. *Learning and Expanding with Activity Theory*, 303–328.
- Engeström, Y. (2015). *Learning by expanding*. Cambridge University Press.
- Engeström, Y. (2016). *Studies in expansive learning: Learning what is not yet there*. Cambridge University Press.
- Evans, R., & Marvin, S. (2006). Researching the sustainable city: Three modes of interdisciplinarity. *Environment and Planning A*, 38(6), 1009–1028.
- Falk, D. R., & Johnson, D. W. (1977). The effects of perspective-taking and egocentrism on problem solving in heterogeneous and homogeneous groups. *The Journal of Social Psychology*, 102(1), 63–72.

- Fjuk, A., & Ludvigsen, S. (2001). *The complexity of distributed collaborative learning: Unit of analysis*.
- Frodeman, R., Klein, J. T., & Pacheco, R. C. D. S. (2017). *The Oxford handbook of interdisciplinarity*. Oxford University Press.
- Gagné, R. M. (1965). *Conditions of learning*.
- Gillies, R. M. (2016). Cooperative learning: Review of research and practice. *Australian Journal of Teacher Education*, 41(3), 3.
- Glaser, B. G., & Strauss, A. L. (1968). *Time for dying*. Aldine De Gruyter.
- Glaser, Barney G. (1992). *Basics of grounded theory analysis: Emergence vs forcing*. Sociology press.
- Glaser, Barney G., & Strauss, A. L. (1967). *Discovery of grounded theory: Strategies for qualitative research*. Chicago, Ill.:Aldine.
- Glaser, Barney Galland, & Strauss, A. L. (1966). *Awareness of dying*. Transaction Publishers.
- Golbeck, S. L., & DeLisi, R. (1999). Implications of Piagetian theory for peer learning. *Cognitive Perspectives on Peer Learning*, 3–37.
- Graff, H. J. (2015). *Undisciplining knowledge: Interdisciplinarity in the twentieth century*. JHU Press.
- Hämäläinen, R., & Vähäsantanen, K. (2011). Theoretical and pedagogical perspectives on orchestrating creativity and collaborative learning. *Educational Research Review*, 6(3), 169–184.

- Hmelo-Silver, C. E. (2013). *The international handbook of collaborative learning*. Routledge.
- James, W. (1907). Pragmatism: A new name for old ways of thinking. *New York*.
- Johnson, D. W., & Johnson, R. T. (1979). Conflict in the classroom: Controversy and learning. *Review of Educational Research*, 49(1), 51–69.
- Johnson, D. W., & Johnson, R. T. (1989). *Cooperation and competition: Theory and research*. Interaction Book Company.
- Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Educational Researcher*, 38(5), 365–379.
- Johnson, D. W., Johnson, R. T., & Stanne, M. B. (2000). *Cooperative learning methods: A meta-analysis*. Minneapolis.
- Johnson, D. W., Johnson, R. T., & Tjosvold, D. (2014). *Constructive controversy: The value of intellectual opposition*.
- Klein, J. T. (2010). A taxonomy of interdisciplinarity. *The Oxford Handbook of Interdisciplinarity*, 15, 15–30.
- Koschmann, T. (2002). Dewey's contribution to the foundations of CSCL research. *Proceedings of the Conference on Computer Support for Collaborative Learning: Foundations for a CSCL Community*, 17–22.

- Latour, B. (1993). *We Have Never Been Modern*. New York: Harvester Wheatsheaf.
- Leont'ev, A. (1978). *Activity, consciousness, and personality*.
- MacLeod, M. (2018). What makes interdisciplinarity difficult? Some consequences of domain specificity in interdisciplinary practice. *Synthese*, 195(2), 697–720.
- Marvasti, A. (2004). *Qualitative research in sociology*. Sage.
- Merriam, S. B. (2002). Introduction to qualitative research. *Qualitative Research in Practice: Examples for Discussion and Analysis*, 1(1), 1–17.
- Miles, M. B., Huberman, A. M., Huberman, M. A., & Huberman, M. (1994). *Qualitative data analysis: An expanded sourcebook*. sage.
- Norman, D. A. (1982). *Learning and memory*. WH Freeman & Co.
- Piaget, J., & Cook, M. (1952). *The origins of intelligence in children* (Vol. 8). International Universities Press New York.
- Pohl, C. (2005). Transdisciplinary collaboration in environmental research. *Futures*, 37(10), 1159–1178.
- Reusser, K. (2001). *Co-constructivism in educational theory and practice*.
- Reusser, K., Pauli, C., & Wright, J. D. (2015). *Co-constructivism in educational theory and practice*.
- Rhoten, D. (2004). Interdisciplinary research: Trend or transition. *Items and Issues*, 5(1–2), 6–11.

- Rittel, H. W., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, 4(2), 155–169.
- Roschelle, J., & Teasley, S. D. (1995). The Construction of Shared Knowledge in Collaborative Problem Solving. In C. O'Malley (Ed.), *Computer Supported Collaborative Learning* (pp. 69–97). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-85098-1_5
- Rylance, R. (2015). Grant giving: Global funders to focus on interdisciplinarity. *Nature News*, 525(7569), 313. <https://doi.org/10.1038/525313a>
- Sawyer, K. (2012). Extending sociocultural theory to group creativity. *Vocations and Learning*, 5(1), 59–75.
- Scott, P. (2016). *Undisciplining Knowledge: Interdisciplinarity in the Twentieth Century*. Taylor & Francis.
- Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational Researcher*, 27(2), 4–13.
- Sharan, Y., & Sharan, S. (1990). Group investigation expands cooperative learning. *Educational Leadership*, 47(4), 17–21.
- Sharan, Y., & Sharan, S. (1992). *Expanding cooperative learning through group investigation* (Vol. 1234). Teachers College Press New York.
- Slavin, R. E. (1978). Student teams and comparison among equals: Effects on academic performance and student attitudes. *Journal of Educational Psychology*, 70(4), 532.

- Slavin, R. E. (1983). *Cooperative Learning. Research on Teaching Monograph Series*. ERIC.
- Slavin, R. E. (1990). Research on cooperative learning: Consensus and controversy. *Educational Leadership*, 47(4), 52–54.
- Slavin, R. E. (1996). Research on cooperative learning and achievement: What we know, what we need to know. *Contemporary Educational Psychology*, 21(1), 43–69.
- Strübing, J. (2007). Research as pragmatic problem-solving: The pragmatist roots of empirically-grounded theorizing. *The Sage Handbook of Grounded Theory*, 580–602.
- Suchman, L. A. (1987). *Plans and situated actions: The problem of human-machine communication*. Cambridge university press.
- Suthers, D. D. (2005). Technology affordances for intersubjective learning: A thematic agenda for CSCL. *Proceedings of Th 2005 Conference on Computer Support for Collaborative Learning: Learning 2005: The next 10 Years!*, 662–671.
- The undisciplinarian: A view From the Bridge*. (n.d.). Retrieved April 7, 2020, from <http://blogs.nature.com/aviewfromthebridge/2015/09/16/the-undisciplinarian/#more-2367>
- Thomas, W. I., & Znaniecki, F. (1918). *The Polish peasant in Europe and America: Monograph of an immigrant group* (Vol. 2). University of Chicago Press.

- Tracy, S. J. (2019). *Qualitative research methods: Collecting evidence, crafting analysis, communicating impact*. John Wiley & Sons.
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard university press.
- Wells, G., & Claxton, G. (2008). *Learning for life in the 21st century: Sociocultural perspectives on the future of education*. John Wiley & Sons.
- Wenger, E. (1999). *Communities of practice: Learning, meaning, and identity*. Cambridge university press.
- Wenger, E. (2011). *Communities of practice: A brief introduction*.
- Wentzel, K. R. (1994). Relations of social goal pursuit to social acceptance, classroom behavior, and perceived social support. *Journal of Educational Psychology*, 86(2), 173.