



Integrated Strategies of Participatory Design and PBL Towards Collaboration Quality

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Abstract. PBL (Problem-Based Learning) as a self-directed learning approach had been widely used in the K12 education area. However, researchers and practitioners still face confusion and challenges on collaboration quality. We defined the problems for such quality through observation at Tongji-Huangpu School of Design and Innovation (THDI). Then the hypothesis that participatory design could improve the quality of collaboration and involvement has been put forward based on related work analysis of integration PD in PBL. The enhancement orientation includes using inclusive and interactive PD approach to improve valuable inquiry clues and group attendance towards high collaboration quality. To analyze the collaboration quality degree and performance based on PD approaches, we took the method of user research for participants who are involved in the PD-driven PBL module at THDI. The research focus factors, effectiveness implementation of integration the participatory design approaches in PBL. We further explored the accessible and efficient strategies for applying such methods in PBL scenario as research findings. This study proposed a theoretical framework which takes the advantages of participatory design towards smooth and efficient collaboration quality in PBL progression, and the research at THDI also has also provided an action paradigm and feasible guideline for similar context.

Keywords: Problem Based Learning (PBL) · Participatory design
Collaboration quality · K12 education
Tongji-Huangpu School of Design and Innovation

1 Introduction

Problem-based learning (PBL) has been a heatedly discussed topic in the cross-disciplinary education area for decades, the practicality and effectiveness of this learning methodology have been validated in various ways. The definition of PBL could be divided into three categories generally: the theory of ‘curriculum,’ ‘instructional strategy’ and ‘a total approach’ (Boud and Felletti 1997; Barrows and Tamblyn 1980). This learning mode begins with a well-designed problem that empowers

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students to construct structured knowledge, critical thinking, problem-solving skills, self-directed learning strategies and collaboration; Such PBL curriculum requires instructors and teachers to have a deep understanding for learning content and scenario. For developers, creating a learning project should contain a variety of background knowledge and possible solutions. The inquiry meditation and driven force could not only turn students from passive recipients into active explorers, but also foster mentors being facilitators and co-learners. As an innovative curriculum, the PBL objective is enabling learners to acquire relevant knowledge, reprocess information and improve their abilities solving similar problems in the living environment or the future work (Barrows and Tamblyn 1980). Compared with a passive knowledge generation method in traditional learning, PBL begins with a complicated inquiry problem which is driven by learners. Depending on this active starting point, knowledge integration and acquisition process could be highly motivational and impressive. The learning objective is to define issues which could represent an incongruity of the phenomenon in real living context. Under this scenario, the self-directed learning topic and framework could enable participants developing solutions with constructive knowledge, the habits of thinking and reflection could also be cultivated spontaneously. Such continuous cycle is a so-called inquiry process (Audet and Jordan 2005). It could not only facilitate a sustainable mode of knowledge generation but also realize a cross-disciplinary knowledge flow among all roles of participants in co-creation context. In one word, PBL is a relevant and sustainable knowledge generation and redefinition process (As Fig. 1). In this cycle, appropriate and effective inquiry problems have to represent students' actual needs, and also enable them to internalize the self-constructed experience into the reproducible and expanding knowledge (Neame 1981).

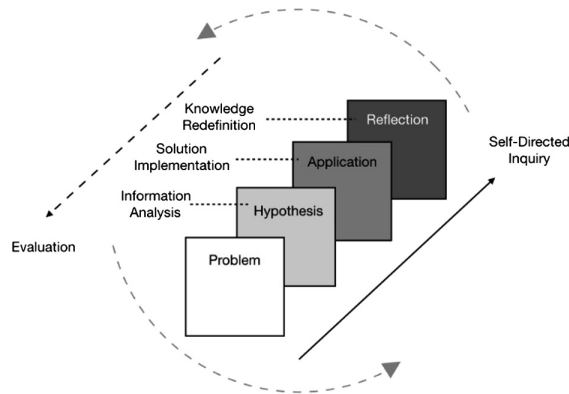


Fig. 1. Problem-based learning cycle

Although PBL has such positive effects on capability building, the collaboration quality is still a research area that not been discussed sufficiently. Participatory design (PD), as an interactive and inclusive approach, has the advantage for different roles involvement and sharing thinking, comments, knowledge, and skills based on the mutual context-understanding (Spinuzzi 2005). Suitable design task could trigger

collaborative learning behaviors for bottom-up knowledge redefinition (Knudstrup 2004). Therefore, some practitioners had tried to take such approaches into PBL to improve individual participation and knowledge diversity in some cases, but there still some confusion about the useful guides for developing such PD curriculums, especially for teenagers in the stage of K12. And there is still a gap between the PD implementation methods and the intervention orientation of collaboration quality. Based on above discussion, the purpose of this study is to clarify such quality and how to use the participatory design approaches to improve this.

2 Challenges and Problems of PBL Collaboration Quality

2.1 PBL Collaboration Quality

In the theoretical area, experts used the California Critical Thinking Disposition Inventory (CCTDI) as measuring criteria for PBL collaboration. Seven qualities are involved in this standard: Truthseeking, Open-mindedness, Analyticity, Systematicity, Critical Thinking Self-confidence, Inquisitiveness, and Cognitive maturity (Margeston 1994; Maudley and Strivens 2000). To achieve this, there are five widely-accepted steps which are: forming a new learning group and creating an acquisition problem, starting the acquisition problem, implementing a problem solving, outcome presentation, and reflection on the learning outcome (Barrows and Tamblyn 1980; Schmidt and Moust 2000; Christensen 2004). However, there is little practice-based research for PBL collaboration quality, especially for the challenges analysis or inspiration methods. Thus, we took the emerging practice of Tongji-Huangpu School of Design and Innovation (THDI), Shanghai China as observation object to define the challenges of PBL collaboration quality.

2.2 Observation and Reflection in THDI Practice

THDI is the first design thinking school founded by Prof. Yongqi LOU in 2016. It was the joint-effort of the College of Design and Innovation at Tongji University (Tongji D&I) and the Educational Bureau of Huangpu District of Shanghai. The aim of this school is to educate the future leaders who can change the world through implementing design thinking across the contexts. In THDI, 60% of the learning in THDI is subject-based, all related to today's Real World Challenges, while the rest of 40% is PBL. These two parts are integrated and interacted closely based on the principles of "design thinking." The key idea is to encourage the students to use the knowledge across the contexts (As Fig. 2) Prof. Yongqi LOU established a team led by Prof. Tiina Laurila of Tongji D&I to develop the curriculum and instructional strategies of the PBL teaching. One of their key agendas is to collaborate and interact with subject-based teaching group closely.

Now, the THDI has been operating for half a year. From the feedback analysis on multiple roles of participants based on the previous two modules, we found the PBL collaboration quality is one of the key challenges of the success. There are two aspects, which limit the integration of the contents with the contexts and then, further limit maximizing the potential of PBL.

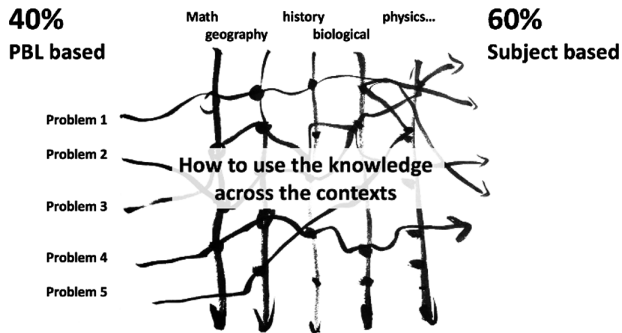


Fig. 2. The framework of curriculums at THDI designed by Prof. Yongqi Lou (Source: hand drawing of Prof. Yongqi Lou)

On the one hand, through the participatory observation, we found students encountered difficulties in defining the suitable line for probing into the underlying problems and generation systematic solutions. Students expected to follow an intended learning guide like filling in blanks in examinations, rather than to design an exploratory framework by teamwork based on problem scenario. Parts of such factors are due to the internal capabilities of group members, but the underlying cause is the attractive clue and common group goal that could arouse sustainable motivation for incremental learning.

On the other hand, we found students were lack of the strong sense of self-driven problem probing and adjustment based on real-time learning progression. Once the ideas or concepts failed to get recognition or agreement in the process of brainstorming, they would lose the strong motivation contributing to the group collaboration and then turned to the negative auxiliary. On the one hand, through the self-evaluation questionnaire after on curriculum module, most students defined their roles as ‘concept supporter,’ ‘follower’ and ‘modelling maker’. Only a small number of students had the strong self-identity and confidence as crucial participants to foster group collaboration towards a right direction. The less of group belonging and cohesion would directly affect teamwork experience and effectiveness when they meet new members. Some inner-harmonious groups also faced limits that there was lack of control on discussion boundary and concepts depth. For example, group chatting sometimes were instead of effective arguing for knowledge generation. Thus, above objective and subjective factors that affect the ideal collaboration quality.

3 Related Works

3.1 Participatory Design Approaches in Education

Under the background of globalization and knowledge-based economy, how to use integrated design methods to involve existing theories and practices actively is becoming an emerging research issue (Lou 2017). Participatory design (PD) is a set of theories, practices, and studies related to end-users as full participants in design

activities (Schuler and Namioka 1993). The technical solution is not a given in PD process, design decisions that shape the solutions should be shared with those who will use it (Bratteteig and Wagner 2012). For users, it allows users to share information and know the whole process; For designers, it helps them understand the unfamiliar scenario and requirements, and develop prototypical solutions with interdisciplinary knowledge and co-defined frameworks (Wilkinson and Angeli 2014). Some PBL practices have introduced design-driven approaches into class to empower participants cooperating with consensus and common targets. Take the case of ‘Mission D’ case at College of Design and Innovation of Tongji University as an example. It aims at cultivating students who are “deep problem solvers in their home discipline but also capable of interacting with and understanding specialists from a wide range of disciplines and functional areas” (Yongqi et al. 2016). The comparison of traditional learning, PBL learning and the PD-driven PBL is as following figure (As Fig. 3).

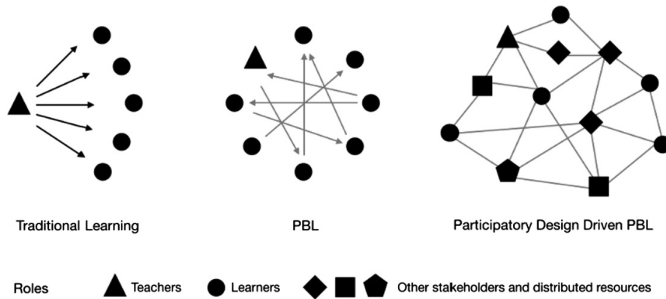


Fig. 3. PD key advantages for enhancing PBL collaboration quality

3.2 Projects Analysis of Integration PD into PBL

Through literature review and the case analysis of the Design Tech High School and NuVu school, we found the common approaches towards smooth and deep collaboration is using PD as an inclusive learning framework and motivation of joint efforts. Take the ‘Design Advisory’ course at Design Tech High School as an example. Students would be encouraged to identify and address real issues in communities nearby. PD acts the key role in cultivating students’ empathy the learning target and framework like users who would benefit from the design solutions. The participatory design task has provided an attractive line of group inquiry with a deep motivation. In this open system, students have involved in entrepreneurship skills cultivation unintentionally and naturally. Another case at the NuVu School represents the PD contributions on multidirectional knowledge flow and participant full contribution with the prototype co-creation and design iteration with users. That means the shared, mutual-help and complementary learning between students with different personalities and capabilities could be realized through the PD-driven PBL courses. Based on above analysis, the collaboration quality enhancement orientation with PD approaches could be summarized as following two aspects:

Inquiry Clues. In the theoretical and practical area, experts and practitioners face difficulties that are how to develop meaning problems to trigger self-motivated learning with inquiry and reflection value (Barrows 2000). As the core of such collaborative behaviors in education, an appropriate clue which is from real lives could illustrate learning target and stimulate curiosity nature with a continuous probing. With this standard goal at the beginning of exploration process, participants would recognize the feasibility and possibility for solution-making in the teamwork (Torp and Sage 2002). It could also be presented as learning needs and sustainable driven force throughout whole learning cycle. Thus, how to design this clue is the most vital part of curriculum development because it directly affects the information gathering among students and restricts the collaborative behaviors among students and mentors.

Group Attendance. Group attendance as another factor including the collaborative motivation and joint efforts on learning participation affect the PBL collaboration quality directly (Van Berkel and Schmidt 2000). Only within well-functioning PBL groups, new knowledge will be constructed and tested through negotiation, leading to true constructivist learning (Savery and Duffy 1996). In this context, students have to achieve common cognitive for the learning task, to experience a sense of interdependence, feel comfortable and encouraged to express their ideas that their group can work in an effective way (Van den Bossche et al. 2006). When they share common goals, they are dependent on and accountable to each other (Johnson et al. 2007; Van der Linden et al. 2000). Such performance of group attendance relates to the knowledge sharing and mechanism to inspire individual's contribution. However, the factors affecting group attendance are quite complicated that could not be solved with a simple approach.

Based on above discussion, researchers and developers need to rethink this tricky problem and develop participatory strategies to empower all stakeholders for knowledge contribution and capabilities complement. Thus, a hypothesis is put forward: the participatory design driven learning task as the intervention into PBL could enhance learning collaboration actively and comprehensively. Firstly, PD as an open system could involve more stakeholders' contribution and relationship reconstruction in a controllable group scope. In this collaboration networks, learners could empathize target users' demands and define the context-based learning frameworks; Secondly, PD as the hands-on activity with interest-orientation and teamwork could provide fruitful inquiry lines to facilitate learners following, defining and exploring learning content. Thirdly, for the new knowledge itself, PD as a dynamic mechanism could foster the pattern transition from one-way flow to peer-to-peer sharing towards an active group collaboration.

4 User Research

To analyze the effectiveness and feasibilities of integration the participatory design into PBL towards high collaboration quality, we designed a PBL course module called 'Creative Communities' at THDI after the previous reflection. The purpose of this module is using PD methods to improve previous collaboration quality challenges like attractive inquiry clues and group attendance performance (As Fig. 4).



Fig. 4. Learning scenarios of ‘Creative Communities’ module at THDI (Source: THDI Teaching Group led by Prof. Tiina Laurila)

4.1 Participants

Analysis results come from the qualitative user research methods of expert interview, students feedback analysis and participatory observation for the collaboration quality insights and evaluation for this module. The course period is 3-weeks which involved forty-eight students, two PBL teachers, two subject-based teachers and one teaching assistant with design background. The roles and responsible work of the interviewees in this module are as following table (As Table 1).

Table 1. Interviewees information

Interviewee	Role and responsibility
Mrs. Xu	The teacher in charge of the class. She manages the learning quality and students real-time feedback and problems in the collaborative learning process
Mrs. Qian	Politics teacher. She is in charge of the integration of subject-based knowledge (i.e. basic financial knowledge and consumer psychology) into the PD design tasks (i.e. business model innovation for a service)
Mr. Ma	PBL teacher. He is in charge of the technical part including using interactive tools for the surrounding environment investigation and prototypes making
Mr. Huang	PBL teacher. He as the facilitator is in charge of leading students to probe user underlying demands and visualization for design concepts
Miss. Zhao	Teaching assistant. She is in charge of supporting the collaborative quality improvement like grouping, task description, team work problems collection and concepts development

4.2 Procedure

We set up a framework of participatory design in this one-month of design course. The first week was to understand design scenario, through the lectures of managers and co-founders of several community innovation projects students got the basic cognitive of the problem of this context and potential design-driven solutions. Then they started the design framework co-creation and brainstorming based on research of surrounding communities to formulate the specific problem to be solved and preliminary concept. In the second week, we facilitated students using model making tools to define and visualize the problems scenario and related users they need to involve in the design process. This tool helped students get insights for people flow, business forms and capital flows in the community around the school during model construction and interaction process. Based on each group’s concept they used the user research and participatory tools to observe, interview and co-create design points with residents in the communities. The third week was the development of design works. Each group used visualization and prototyping methods to realize their concepts, such as rescue service design for community pets, tourism information interactive design in old streets, design for sharing leisure space in communities, redesign for telephone booth and the intelligent parking system design. In the final report, teachers and part of target users were invited to sharing ideas, comments and suggestions (Fig. 5).

CREATIVE COMMUNITIES															
FOCUS	*YOU* focus on interaction and collaboration qualities in design process to foster the community creativity WEEKS 8,9,11 (WEEK 10, Mon 6/11, Tue 7/11 sports, Wed, Thu, Fri Exams)														
Week	8. Cultural Heritage and Urbanism					9. City Scope workshop					11. Entrepreneurial Service and Creative Communities				
date time	Mon 23/10 2:55-4:25	Tue 24/10 2:55-4:25	Wed 25/10 2:55-4:25	Thu 26/10 2:55-4:25	Fri 27/10 1:10-4:15	Mon 30/10 2:55-4:25	Tue 31/10 2:55-4:25	Wed 1/11 2:55-4:25	Thu 2/11 2:55-4:25	Fri 3/11 1:10-4:10	Mon 13/11 2:55-4:25	Tue 14/11 2:55-4:25	Wed 15/11 2:55-4:25	Thu 16/11 2:55-4:25	Fri 17/11 1:10-4:10
if more time needed Mon-Thu can be extended to 5:15	Cases Sharing of Creative Communities and Approaches to Foster Old Community Creativity	Urbanization and Cultural Heritage	Design Harvest Project on Chongming Island	Basic Knowledge of Open communities and Service Design	Visit to Shanghai Urban Planning and exhibition Centre	Map that matters- introduction of the task and mapping of experience around the school	Using City Scope to illustrate the values, spatial properties of the environment	Presenting CityScope and starting to make design prototypes	Prototypes Improvement	Presentations for Design Issues to Foster the Community Creativity with the City Scope	Problems to trigger an entrepreneurial service, Business modelling	Concept generation, Service Blueprint Drawing	Group Collaboration, Touchpoints Visualizations	Prototype Making (sketches, collage, models, performance)	Exhibition of the students' design processes and results in High School
WHAT?	Learning of the development of the urban-rural environment, systems and creative open communities					Experiencing the City Scope tool for designing the urban environment					Learning to develop the business concept based on the learnings and experience in the previous weeks and presenting the work in an exhibition				

Fig. 5. ‘Creative Communities’ module at THDI (Source: THDI teaching group led by Prof. Tiina Laurila)

We listed the interview framework to collect participants’ feedback after this course. To study the feasibility, effectiveness, and weakness of PD approaches towards

PBL collaboration quality, the interview questions for teachers focus on following aspects, and the feedback of interview is shown as Fig. 6.

- Compared with general PBL, what are the contributions of PD courses to students' collaboration motivation, enthusiasm, and effect?
- Compared with the previous PBL courses, does the PD task give students better learning guide and research clue to define solutions and construct context-based knowledge? How does PD achieve this?
- In collaborative learning, does every team member has sufficient knowledge or skill contribution to the group work through integration PD methods into PBL? Any complaints or problems?
- In the process of PD, what design topic is the most enthusiastic to trigger the group collaboration and idea sharing? What type of issue has negative effects on group discussion and concept development? What are the causes of such problems?

The interview questions for students focus on the following aspects:

- What is the self-definition of your role in the group collaboration?
- What is the performance and development of your team members in this design process?
- What is the crucial point motivating you and your team members to engage in the collaboration? And what is the barrier to sharing ideas and developing concepts in the teamwork?
- What is the improvement or iteration orientation of your group design work?

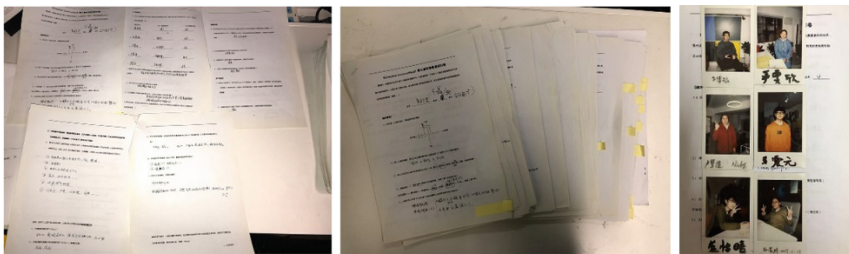


Fig. 6. Interview feedbacks (Source: photography by the authors)

4.3 Results

Through the card sorting and summarization for interview information, we classified the feedback data into four main aspects including the users' points of view, affecting aspects of the collaboration quality, attributes of this quality and the PD contributions in this process (As Table 2).

Table 2. Effectiveness and feasibilities of PD approaches towards PBL collaboration quality

Users' points of view	Affecting aspect of collaboration quality	Attribute	PD contributions
<p>Attractive and well-designed grouping in this PD course has greatly improved students' motivation of teamwork. Collaboration with new partners has inspired the complementary skills cultivation</p>	<p>Group attendance</p>	<p>Capability and personalities matching</p>	<p>Random grouping game based on students' participation like self-cognitive and self-evaluation</p>
<p>Instead of the top-down assignments in traditional PBL, the integration the subject knowledge into the design task has triggered student context-based knowledge acquisition in specific learning progression impressively</p>	<p>Inquiry clue</p>	<p>Context understanding with inquiry lines</p>	<p>Offering a divers and complex inquiry line for learning and solution making in collaboration with other disciplinary teachers</p>
<p>Compared with the traditional PBL, the fewer technical requirements and professional restrictions of PD tasks allow everyone to touch the methods and imagine potential outputs. Thus, it has inspired all participants' joint efforts for developing final works. Especially for some marginalized members of the weak participation, they are also divided into reasonable tasks and encouraged to input ideas collaboration actively</p>	<p>Group attendance</p>	<p>Capability division; Teamwork congruence (encouragement & motivation)</p>	<p>The depth and scope of PD concept development is flexible that different students with diverse personalities and learning habits can get the rational capacity matching</p>
<p>A good PD task has facilitated the sustainable and continuous learning beyond the course and school, students have inspired to search further information to improve their dissatisfied concepts and find resources like NGO, social activities or organizations for implementation and iteration</p>	<p>Inquiry clue</p>	<p>A degree of complexity, diverse and iteration of inquiry clues</p>	<p>PD could foster the knowledge into action, knowledge flow and the relationship reconstruction. As an interactive inquiry clue, it has been proved in this process and has profound effects on learners</p>

5 Findings

5.1 PD Characters Affecting Collaboration Quality

Contextualization and Complexity of Inquiry Clues. Firstly, at the start point of a PBL inquiry process, a PD task could give a clear description of the research content which has inner-linked problems and potential approaches to solve the problem at the same time. It illustrates the content related to a realistic context that could trigger common understanding and deep empathy sense. For instance, such context-based understanding could include the incongruence, which means contradictions and conflicts in a situation or phenomenon. Like the relationship reconstruction issues in immigrant communities, if students face to this learning topic, they need to inquire cultural, economic and psychological reasons for the involvement and self-identity of the excluded groups. Behind this scenario, they could learn complicated social problems and build collaboration behaviors from bottom up. Moreover, a suitable and interactive inquiry clue under the PD task also have a degree of complexity which means diversity, difficulty, and tolerance for potential solutions and design methods. It emphasizes to activate every participant's contribution towards a strong passion and exploration willing with a common using scenario for design outputs. For instance, PD could foster complex clues with accessibility include a problem to be solved, a topic of the design output, the channels and methods, the technical and cultural conditions required, the resources and partners, the job division of team members, and the alternative concepts. The complexity also should consider the active communicating environment for brain-storming to avoid too weak or too straightforward topic.

Capability Matching Towards Group Attendance. To empower and activate the individual knowledge and skills construction, the attractiveness, participation and feasibility mechanism for capabilities matching has to be taken into account. PD as self-driven creative activities allow diverse forms for gamification grouping, task division and collaboration scope. On the one hand, through self-cognitive and existed knowing for students, multiple design tasks could attractive students with differentiated personal abilities and knowledge reserves into suitable groups, they would search partners with complementary skills to achieve high learning experience and quality, such skills like illustration concepts, technology for prototypes making, presentation, leadership for efficient work or knowledge in particular subject could be divided reasonably. On the other hand, the high participation could enable the random and interactive grouping methods to ensure the collaboration scope and depth. From the THDI, mentors used ice-breaking activities and grouping games based on tangible products co-creation or student mutual evaluation to divide optimists, introverts, cooperators or mavericks into suitable teams had achieved positive effects on teamwork.

5.2 Implementation Strategy

PD implementation strategies which are integrated into PBL to enhance the collaboration quality are abstracted as three inner-linked and continuous steps based on above factors. They include empathy for inquiry context understanding, capability-based

grouping towards group attendance, and relationship reconstruction towards further collaboration.

Empathy for Context Understanding. With the goal to achieve context understanding for inquiry clues, mentors have to use PD empathy approaches to guide students where an inquiry problem comes from, what is the cultural or physical factors or limitations, and who are target users relating to this context. This strategy needs mentors guide students to apply empathy design methods like the participatory observation, focus group interview and user profiles on simulating pain points, demands, and benefits that users would face too. The aim of this strategy is turning students' roles from objective observers into stakeholders, from spectators to the people who will be spontaneously involved in this matter based on empathy stage of PD. For instance, students could draw user profiles to understand strange or professional scenario visually following three questions: (1) What is the context that users will choose your products? (2) What is the situation without using such products? (3) What is the thinking pattern, emotional factors and using behaviors of your target users?

Capability-Based Grouping. With the self-defined clue and iteration feature of PD, bottom-up concepts creation is instead of the top-down education. A suitable grouping mechanism in this particular specific design task could ensure the smooth and efficient teamwork of different skills and personalities. It aims at using interactive grouping methods without obvious mentor-interference but under well-designed to trigger the contribution of every group member. An important part of grouping is capability-based mode to train students adaptability and leadership for challenging missions. This requires mentors design grouping games to encourage students jumping from their comfortable zone or familiar friends to apply their proficient skills into a designated group collaboration. An interactive and self-directed grouping game through PD clues attributes is shown below (As Fig. 7). Other potential grouping index like engineering, programming, perception thinking or deep insights also could be taken into consideration.

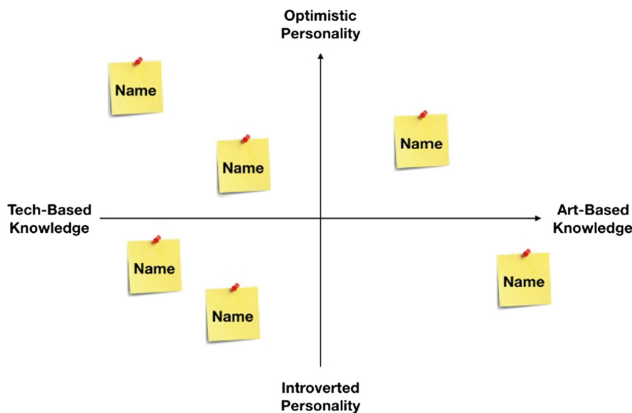


Fig. 7. Example of grouping method

Relationship Reconstruction. This strategy is using PD activities to build sustainable learning communities for teacher role transformation and teacher-student relationship reconstruction. In this context, ‘Reconstruction’ refers to the flat teacher-student relationship instead of the leader-receipt relationship. It requires teachers turn the role into the active collaborators, experienced participants, and academic guides from the one-way information communicators. The self-cultivate probing skill is necessary for this context which is discovering the weakness in group collaboration and making intervention solution instantly. This also requires mentors have a full understanding of students’ existing knowledge and ability reserve based on collaboration performance. During the learning progression, mentors have to give promotion suggestions, counseling guides and constraints according to specific design task, and also guide students to contact related stakeholders to define solutions. Besides, teachers also could renew learner profiles and self-improvement during quality tracking with real-time assessment tools to further learning after the courses. With PD methods to create, develop and improve concepts with target users, the hierarchy of collaborative relationship between students and other stakeholders like residents, managers or other partners need to be break. This strategy needs teachers facilitate peer-to-peer learning communities beyond the school and turn their roles from simple leadership role into co-creators.

6 Conclusion

Through the critical literature review and the observation of practice at DHDI, we defined the PBL collaboration quality problems. Through related work analysis for practice of integration PD into PBL, this research put forward the quality enhancement orientation including inquiry clues and group attendance. Then the research hypothesis which is participatory design could solve problems of attractive inquiry clues and the group attendance towards high PBL collaboration quality. With such concern, we collected THDI as the user research object to analysis PD feasibilities and approaches based on the redesigned PBL module with PD approaches. Based on participatory observation, interview for participants and feedback collection from students and teachers, the feasible PD implementation strategies for integration of PD advantages into PBL methodology as the core research findings are put forward. It is the theoretical and experiment response to previous research questions including participatory design factors affecting PBL collaboration quality and the accessible application guidelines. This study provides a context-based action paradigm for researchers and developers who face related problems in PBL practice, and it also extends the application PD diversity and depth for other similar scenarios.

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