

# A Cross-Cultural Perspective to Creativity in Engineering Education in Problem-Based Learning (PBL) between Denmark and China\*

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This paper takes a cross-cultural perspective to link a study on creativity development in engineering education in a Problem-Based Learning (PBL) in Denmark and its implications for fostering creative engineers in China. The analysis of empirical data, drawn from a Ph.D. study (2008–2012), aims to answer the two research questions: (1) what are the advantages and disadvantages of PBL in fostering creative engineering students in the Danish context? and (2) what are the cross-cultural implications of fostering creativity in engineering education by PBL in Denmark for China? The results suggest that in the Danish context, PBL is helpful for creativity development by stimulating motivation, developing skills such as communication, critical thinking, leadership, etc. But disadvantages exist, such as students having poor conceptualization of creativity and poor confidence in being creative. This has an implication in China: PBL requires that the relationships between teachers and students and between students needs to be reconstructed. To break the Chinese culture's barriers to creativity is the key to reconstructing these relationships.

**Keywords:** creativity; Problem-Based Learning (PBL); engineering education; cross-culture study

## 1. Introduction

In general, creativity involves the ability to offer new perspectives, generate novel and meaningful ideas, raise new questions, and come up with solutions to ill-defined problems [1]. In today's rapidly expanding global competition, there is a continuing and ever-growing recognition of creativity. For example, in his newly published *How Creativity is Changing China*, Li [2] pointed out that in the wake of China's integration into the global economy, regional development is occurring in many parts of China. In these regions, creativity is changing China's established management models and reforming its ways of thinking. As the shift from 'Made in China' to 'Created in China' is underway, China is moving towards a creative society, which is a more specific indicator of cultural progress than the slogan 'harmonious society', which is used to refer to all facets of people's life.

The engineering of the distant past was perhaps more of an art than being akin to science, as we think of it today. Engineering builds things up, often as unique creations. This can herald their existence as works of technology and statements of art. There are many pressures, some of them increasing, facing engineers and engineering education today—from funding bodies, professional institutions, government bodies and industry. These suggest that engineers need to develop wider and more responsive skills and approaches to engineering in its social

context, in fact they need to revisit the ability to discover creative solutions to engineering problems [3]. As emphasized by *The Engineer of 2020* [4], future engineers need 'creativity', which is the ability to respond to challenges by combining learning a broader range of interdisciplinary knowledge in new ways and a greater focus on systemic constructs and outcomes. Therefore, one of the most important factors for creative engineers in a creative economy is education. This is the reason why engineering education has started focusing and developing students' creative abilities and skills. The engineering students are expected to apply what they learn in new and creative ways, so as to ensure continued productivity, economic growth and social welfare [5].

From a policy perspective, there is ample evidence of a recent emphasis on Chinese creativity education among educators, scholars and policy makers [6]. For example, in September of 2010, Hu Jintao emphasized the value of educational innovation when speaking to the teachers [7], 'innovation' being a policy term that is preferred to 'creativity' in China [8]. Recently, the new concepts such as development of multiple intelligence, use of discovery learning, and use of humour in teaching, etc. have been emphasized in the study [9]. The new pedagogical strategies aiming to put engineering education innovation into practice have also been explored in China. For example, Problem-Based Learning (PBL) has been indicated as one of the

potential pedagogies of fostering creative engineers in China [10–12]. Meanwhile, the institutions in engineering education in China are aiming at globalization by involving themselves in collaborative projects with institutions in other countries. For example, there are growing collaborative interests in higher education between China and Denmark. Since 2010, the Sino–Danish Center (SDC) for Education and Research has provided a platform for jointly undertaken research activities and exchange of scientific staff in higher education between China and Denmark. It has been agreed that the initial research activities of SDC fall within five major research themes; these include Water and Environment, Renewable Energy, Nanoscience, Life Sciences, and Social Science [13]. Such increasing collaborative interests bring the benefits of development of engineering education, as well as the challenges of the cross-cultural issues to the partners involved.

Following the above points, this paper takes a cross-cultural perspective to discuss creativity development in engineering education in Problem-Based Learning (PBL) between China and Denmark. To involve the two contexts in this study is firstly the result of the growing collaborative interests of engineering institutions between China Denmark, as already mentioned. Secondly, this is due to the fact that some universities in Denmark are popular as they use PBL in engineering education [14], which may imply better use of PBL in China.

However, it is necessary to give a brief introduction to PBL. As discussed in the literature [14], the term Problem-Based Learning (PBL) was originally coined by Don Woods [15], based on his work with chemistry students in McMaster University in Canada. However, the popularity and subsequent worldwide spread of PBL is mostly linked to the introduction of this educational method at the medical school at McMaster University. Recently, PBL has been introduced into education in many professional fields and appears to be of growing interest to engineering education [14]. Theoretically, the constructive learning principle emphasizes that learning is an active process in which students actively construct or reconstruct their knowledge networks. Learning is also the process of creating meaning and building personal interpretations of the world based on individual experiences and interactions [16]. In practice, students' learning centres on complex problems that do not have a single answer or solve real-life projects. Students work in collaborative groups to identify what they need to learn in order to solve the problems. The teacher acts to facilitate the learning process rather than to provide knowledge [17]. Although there are diverse models of PBL around the world, 'student-

centred learning' has been regarded as the core principle and as the basic condition of creativity development [14].

Undoubtedly, education is a social–cultural process. This means the process of borrowing educational practice from another culture implies an acceptance of cultural values [10]. Meanwhile, the researchers [18, 19] working in the framework of social–cultural theories also have argued that due to the influences of Confucian values, Chinese learners have different styles of creativity to those of the learners who are influenced by Western values [18]. So cultural factors must be considered when introducing the Western methods of teaching creativity to China, since the cultural constrains of PBL in China exist. However, challenges of educational changes towards PBL in China have been mainly discussed at the levels of curriculum and institution [20], less attention has been paid from a cultural perspective. So this paper aims to bridge the issues of PBL application in engineering education between the cultural values of the East and the West, based on a Ph.D. study (2008–2012) [21] in relation to group creativity development in engineering education in the PBL environment in Denmark. Aalborg University (AAU) was the research context that has a long tradition of PBL. So two particular research questions will be asked in this paper:

1. What are the advantages and disadvantages of PBL in fostering creative engineering students in the Danish context?
2. What are the cross-cultural implications of fostering engineering students by PBL in Denmark for engineering education in China?

In order to answer the first question, data collected in the Ph.D. study [21] will be re-analysed. The data includes interviews with 53 students from Computer Science, Electronic Systems, Architecture and Design and Medialogy at AAU. It also includes a case study in a student satellite project in the Department of Electronic Systems at AAU. The results of data analysis will lead to discussions for answering the second question. As mentioned above, this paper contributes firstly to creativity development in engineering education in both the contexts of Denmark and China and secondly to implications for fostering creativity in engineering education in other cultural contexts.

## **2. Creativity, Eastern–Western cultures, and PBL in engineering education**

### *2.1 Creativity and Eastern–Western cultures*

Although any creative ideas are generated from a person's mind; creativity does not occur in a

vacuum. This means that when we examine a creative person, creative product, or creative process, the environmental milieu cannot be ignored [22]. According to Mayer [23], creativity can be regarded as a context-based activity: it cannot be dissociated from its social, cultural or evolutionary context. For example, Csikszentmihalyi [24] argues for a system model of creativity that involves a complex interaction between a person, a field and a culture. When focusing on making comparisons, the contextual approach may compare creativity in different cultures [23].

For example, studies [25, 26] showing a tendency for people from Confucian societies in the East to be less creative than people from Western society may indicate that there are elements within Confucianism that inhibit creativity. Confucianism is the major cultural influence in Chinese-influenced areas, including China, Korea, Japan, Vietnam, Hong Kong, Singapore, and Taiwan, etc [27]. Kim [27] explored the interactions between Confucianism and creativity in a literature review arguing for four principles of Confucianism and the ways they conflict with creativity:

1. The principle of *Emphasis on Education* inhibits creativity through rote learning, extreme competition, a work–play dichotomy, and a devaluation of play.
2. The principle of *Family System* blocks creativity through strict gender role expectations, rigid parent–child relationships and an overemphasis on obedience, filial piety and loyalty.
3. The principle of *Hierarchical Relationships* decreases creativity through unequal relationships, rigid social structure, gender role expectations and the authoritarian relationship between teachers and students.
4. The principle of *Benevolence* stifles creativity through suppression of emotion, the silence ethic, and extreme value of humility, conformity and stigmatised eccentricity.

However, strengths of fostering creativity by collectivism have also been figured out. For example, there is a greater emphasis on meeting a shared standard so as to maintain harmony in one's relationships to the group. Therefore, the collectivistic groups are to be high in collaboration and achievement of collective goals [19].

In contrast to the collectivistic values in Eastern societies, individualism has been argued for a better cultural value for a creative climate [19]. For example, as Kim [27] pointed out, it is harder for Asians than Westerns to think, feel, and act in a creative manner because Asian society is tightly organized, collectivistic, hierarchical and face-conscious. He also described how the American educational

system encourages the exercise of creativity by providing an environment that promotes free and open discussion. Educators have flexibility and freedom because of their rights and their academic freedom. Craft [28] emphasized that the organization of the curriculum is likely to offer opportunities for learner engagement. Attention will be paid to ways in which adults and others with more expertise and experience can intervene to nudge creativity forward with reference to the learner's perspective in particular. Such a learning culture is what the individual values emphasize—people are viewed as independent and possessing a unique pattern of traits that distinguish them from other people [19]. Such a cultural orientation may actually help groups to meet the requirements of creativity and innovation. However, the individual group may at times appear to be divisive and even unruly, which further increases group disagreement, delays the group decision process, and decreases creativity in the collaborative context [27].

## 2.2 PBL as an educational strategy of creativity development

PBL is supported in many ways by theories in the learning sciences, ranging from constructivism and cognition to problem solving. These theories have also been involved in the discussions on creativity development in PBL [21]. For example, Tan [29] provided a comprehensive understanding on why and how creativity can be fostered by PBL from different perspectives such as cognitive, social-cultural, psychological, and social-psychological.

According to Zhou et al. [30], there are at least three aspects of PBL that can stimulate creativity: 1) problem orientation and project work, 2) group learning context, and 3) the shift from teaching to facilitation. From the aspect of problem orientation and project work, Tan and his colleagues [31] emphasize that the problems are the drivers to creativity and lead to cognition and learning. A problem triggers the context for engagement, curiosity, inquiry, and a quest to address a real-world concern. In the project work, the motivation for creativity can be increased and, at the same time, students can learn interdisciplinary knowledge and other skills related to creativity, such as communication, critical thinking, leadership, and collaboration etc [30]. From the point of view of group learning, Poikela et al. [32] pointed out that the PBL process begins with students working toward a shared understanding of the problem presented to them. They then brainstorm ideas about the content area related to the problem using their existing knowledge and prior experience. So PBL offers a framework for structuring and facilitating learning and group processes based on creative problem

solving. In regard to the shift from teaching to facilitation, Zhou and her colleagues [10] emphasize developing creativity in the learning context, the principle of ‘student-centred learning’ should be followed, which can increase the ownership of learning and can further stimulate creativity.

In addition, situations caused by the ritual behaviour in groups that can be barriers to students’ creativity should be avoided in PBL contexts. For example, sometimes the students do not activate their prior knowledge, do not decide themselves what is relevant for learning or cannot discuss the subject matter studied with others [33, 34].

### 2.3 Application of PBL in engineering education

Besides the particular focus on creativity, the literature [16] also discussed the other skills that the students can improve through PBL. For example, the students have opportunities for constructing extensive and flexible knowledge, developing effective problem-solving skills, becoming effective collaborators and developing self-directed learning skills, etc. Due to the effectiveness of multiple skills in student learning, PBL has been employed in many universities around the world [35]. According to the earlier numbers provided by Samford University in 2000 [36], there were more than 100 undergraduate institutions with faculty members using PBL. Those institutions involve universities in areas of the United States, Australia, Belgium, Canada, Denmark, the Netherlands, Hong Kong, Sweden and the United Kingdom, etc. Most of those institutions have covered the educational field of engineering. However, the recently published work [35, 37, 38] indicates that PBL is an instructional approach that has drawn more and more attention to education and continues to gain acceptance in multiple disciplines.

However, due to the diverse educational cultures, PBL in engineering education has been discussed with its different models, and distinctions between the models [37–39]. For example, Savin-Baden [39] has operated with five models of PBL:

1. PBL for epistemological competence
2. PBL for professional action
3. PBL for interdisciplinary understanding
4. PBL for trans-disciplinary learning
5. PBL for critical contestability.

Moreover, as solving real-life projects has become one key way to organize learning in PBL, there are discussions on the differences and relationships between Problem-Based Learning and Project-Based Learning. Some literature [15] has argued for Problem-Based Learning to be an overall educational strategy used in institutions, while Project-Based Learning is used as a method in classrooms.

This has been epitomized by all the five models of Savin-Baden [39] by the fact that Problem-Based Learning and Project-Based Learning may vary to a certain degree, inviting people to develop mixed models such as are practiced around this world. So some researchers [40] have regarded PBL as an umbrella term for both the approach of Problem-Based Learning and of Project-Based Learning. For example, Mills and Treagust [41] discussed the application of Problem-Based Learning and Project-Based Learning in engineering education with especial focuses on the effectiveness and relevance of each method. However, a mixed-mode approach has also been proposed as a potentially successful strategy to be used in the future.

In China, PBL has been used in diverse fields in higher education such as Analytical Chemistry [42], Anatomy [43], and Mechanics [44], etc. Among the diverse fields, medical education has a longer history of PBL in China [45]. In engineering education, PBL is mainly used on the curriculum level [44]. However, the recent studies have argued the tendency for changes towards PBL theoretically [10]. Researchers such as Zhou and her colleagues [10] figured out that PBL should be a potential model of fostering creative engineers in order to overcome the barriers of Project-Organized Groups to creativity in China. In practice, the increasing number of establishment of centres for student innovation in engineering universities also underpins such changes from the organizational aspect. For example, the main aim of the Center at Northeastern University in China is to provide engineering students with as many as opportunities of participating in real-life projects, supported by both national and regional governments [46]. However, it is claimed that Chinese students are used to traditional teaching methods, are resistant to the unfamiliar technique of PBL, and cannot adapt to it over a short period of time [44, 47].

## 3. Empirical work at Aalborg University (AAU), Denmark

### 3.1 The PBL model at AAU, Denmark

The Danish PBL tradition dates back to the 1970s. In 1974, Aalborg University was founded on a new educational model of PBL. It should be noted here that the Danish approach to PBL is that it is a combination of a Problem-Based and a Project-Organized approach [48]. The project work model is used in all study programmes at Aalborg University within the Faculty of Humanities, the Faculty of Social Science, the Faculty of Engineering and Science and the Faculty of Medicine.

The curriculum is organized into semesters—ten

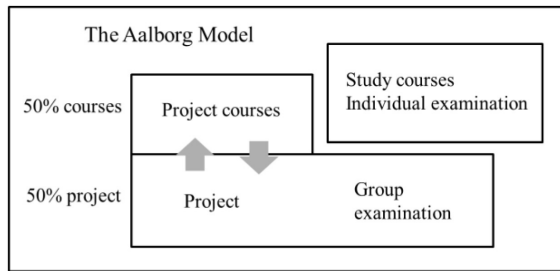


Fig. 1. The traditional Aalborg PBL model.

semesters leading to a Master's degree. In each semester, the project and the majority of the courses must relate to the theme of the actual semester. The students are supposed to attend the courses and apply them in their project work, and the output of the courses is assessed, along with the project report at the end of the semester. The examination is a joint group examination with individual marks and takes up to six hours. The work with the project report and courses—the theme—covers approximately 80% of the semester, equivalent to 24 ECTS (European Credit Transfer System). A full semester is 30 ECTS points. The rest of the semester includes fundamental courses or other compulsory course (study courses) assessed by more traditional examinations [49] (Fig. 1).

In the last few years, AAU has become more and more popular with its PBL model around the world, especially in Northern Europe. As Kolmos and Holgaard [50] pointed out, this is due to the fact that AAU is ranked as the top university in developing engineering education according to the needs

of the labour market, together with its extensive PBL environment. The selected empirical work from a Ph.D. study [21] on creativity in this paper also regarded AAU as a research context.

### 3.2 Selected empirical work from a Ph.D. study on creativity at AAU

As mentioned previously, this paper draw it research resource from a Ph.D. study [21] that was carried out during 2008–2012. The Ph.D. study [21] choose the PBL model at AAU as the main research context and students and staff from study programs in the Faculty of Engineering and Science as participants for data collection. Table 1 shows the details of the selected empirical work in the Ph.D. study [21].

As Table 1 shows, the total number of participants in the selected empirical work from a Ph.D. study [21] is 67. The participants are labelled from P1 to P67 in data management. They came from both the long-term project like AAUSAT3 ( $n = 14$ ) and normal semester project ( $n = 53$ ) at AAU. Four educational fields have been involved: Electronic System, Computer Science, Architecture and Design, and Medialogy. The data collection used multiple methods such as interview and observation; however, data from interviews will be the main data resource; data from the observation will be the complementarity of interviews. The original research question in the Ph.D. study [21] was: How do engineering students develop group creativity in a PBL environment (in Denmark)? As this paper proposes new research questions these are different from the original one in the Ph.D. study

Table 1. Selected empirical work in a Ph.D. study as a research resource

Topic	Group creativity development in Problem and Project-Based Learning(PBL) environment in engineering education
Research context	Aalborg University, Denmark
Research time	2008–2012
Research questions	How do engineering studens develop group creativity in PBL environment (in Denmark)?
Research aims	The intention of the Ph.D. study was to find out how the PBL environment influences creativity of student groups in higher education.
Theoretical perspective	Social-cultural perspective to creativity
Research methods	Qualitative methods
Data resource	53 interviews with students from Computer Science, Architecture and Design, Electronic System, and Medialogy at AAU . The students came from the third, fifth and seventh semester. The interviews focused on how the students perceive their individual contributions to group creativity and how the group process influences their individual creativity in the PBL context. 14 interviews (12 with students and 2 with supervisors) and observation (across three semesters) in a student project AAUSAT3*. The interviews focused on how the students and their supervisors think of influences of PBL on their motivation of creativity development in project groups. The observation focused on the students' group meetings and processes of solving problems in their daily learning life.

\* AAUSAT3 is the third student satellite that was started from 2007 and was launched late 2010. The mission of the satellite project was to carry out and operate the Automatic Identification System (AIS) play loads aiming to be used by ships to communicate between each other. AAUSAT3 has a joint venture with several departments including the Department of Electronic Systems, the Department of Mechanical Engineering, the Department of Computer Science and the Department of Energy Technology. Students from the 1st to 10th semester were encouraged to participate in AAUSAT3 according to the different rate of the tasks.

[21], the empirical data shown in Table 1 will be re-analysed according to the transcription, which will also lead to the following findings and discussions.

## 4. Findings and discussions

### 4.1 Advantages and disadvantages of PBL in fostering creativity in Denmark

Both the interview data and observation data show that in the AAU PBL model, some effort has gone into installing a creative learning environment where there is an atmosphere which stimulates motivation, open-mindedness, risk taking, ownership, freedom and psychological safety and where young students can easily express their creativity. However, the interview data demonstrates that *laissez-faire* exists in project supervision; some students have very poor conceptualization of creativity and little confidence in being creative and they lack of knowledge of creativity techniques in the problem-solving process. There is also a lack of negotiation of teaching creativity between different educational fields. Such advantages and disadvantages of PBL in fostering creativity can be summarized in Table 2.

The findings shown in Table 2 have underpinned what some previous work has discussed, such as Zhou et al. [30]. Four elements can be understood as the roots of gaining an advantage, but meanwhile causing the disadvantages:

1. the core philosophy of 'student-centred learning',
2. group learning,
3. project work, and
4. the facilitation of supervisors.

These aspects bridge creativity and PBL at AAU.

As mentioned previously, 'student-centred learning' is the core philosophy of PBL. For example, in the case of AAUSAT3, students were involved in

the management of learning activities. What the students introduced into the interviews, the project proposals, were announced on the website (<http://www.ausat3.space.aau.dk>) at the beginning of every semester. Students who were interested in this project gathered to discuss the possibility of group establishment, which can be described as a 'peer-arranged' process. The students initiated meetings and decided how to participate by themselves. So AAUSAT3 is conducive to building a community, where groups of people work together with a common set of goals or interests [32]. Accordingly, the ownership of learning is increased, which is a key to creativity development. As Craft [28] suggested, the creative learning environment should offer opportunities for students to ask questions, identify problems, determine lines of enquiry, generate their own ideas and draw thoughtful conclusions. It will also offer opportunities to construct and co-construct knowledge, as well as opportunities to use it to develop perspectives, collaboration and co-construction. Thus, a series of creativity-related skills can be improved, such as self-directed learning, social skills, communication, leadership, project management, critical thinking etc. These points can be evidenced by the interviews:

I learn from the others and am motivated by the others in the group. Sometimes you should be critical to judge the others' new ideas and to easily say 'yes' is not much welcomed by the group. But if I meet the critical comments, I will try to argue my ideas and let the others know they are possible to be realized in practice. And then the group may turn to the experiments. (P21, from Electronic System)

To be creative sometimes means to be different from the others. But it also means the design ideas are supported by the others. This may force you to communicate with others for a good illustration and deep understanding of those ideas. (P65, from Medialogy)

I think we learn from how to manage the problems. We usually try to take a problem into parts. Maybe we have the disagreement in looking for solutions but it is

**Table 2.** Advantages and disadvantages of PBL in creativity development

Advantages	<ul style="list-style-type: none"> <li>• Stimulate motivation</li> <li>• Stimulate creative climate</li> <li>• Encourage peer learning in group work</li> <li>• Increase ownership of learning</li> <li>• Ensure psychological safety in asking questions</li> <li>• Stimulate open-mindedness</li> <li>• Encourage risk taking in problem-solving process</li> <li>• Stimulate interplay between individual and group creativity</li> <li>• Provide comfortable learning environment which fosters humorous and playfulness</li> <li>• Foster creativity-related skills such as self-directed learning, communication, leadership, group work, project management, social skills and critical thinking, etc.</li> </ul>
Disadvantages	<ul style="list-style-type: none"> <li>• Students have poor conceptualization of creativity</li> <li>• Students have poor confidence of being creative</li> <li>• Students lack of knowledge about creativity techniques</li> <li>• Laissez-faire exists in project supervision</li> <li>• Lack of negotiation of teaching creativity between different fields</li> </ul>

normal. Everyone tries to explain his (or her) own points until the whole group gets the satisfying decision. This means you should be independent but meanwhile you are in the group. (P35, from Architecture and Design)

Group learning also provides the conditions of developing creativity and other creativity-related skills. According to the interviews, students in one group are not only learning partners but also friends, especially in the long-term learning community. Shared leadership has been realized in groups, which means every member is responsible for parts of project tasks. The individuals' motivation is improved and peer learning is encouraged. As Eteläpelto and Lahti [51] describe, in the successful collaborative settings, participants build on each other's ideas in order to reach an understanding that was not initially available to any of the participants. They must also enter into critical and constructive negotiation of each other's suggestions; well-grounded arguments and counter-arguments need to be shared and critically evaluated through collective talk. These conditions are similar to those needed for collaboration in creative endeavours. As students described their learning experience in the interviews:

It is hard to say who is more important than the others in the group. I am working between individual jobs and group work—we need different skills from the group and at the same time we contribute individual skills to the group. Everyone wants to try his (or her) best for the group. It is more like a collaboration than a competition between the group members. (P10, from Computer Science)

I think group learning is really a good way to learn from each other and learn to check how the group can do and how the individuals can contribute to the group work. Although we only have four members, we need a lot of communication in the group. We always keep on discussing with each other, which is helpful to understand each other's points and sometimes new ideas come out of such group discussions. (P23, from Electronic System)

Meanwhile, all learning activities of students centre on project work. Progressing through projects leads to the achievement of both individual and group learning goals. Thus a metaphor can be used here that describes a project as one 'extra member' in student groups. Both interview data and observation data indicate that students' creativity is developed out of 'conversations' between students and the 'extra group member'. The conversations are 'back and forth' processes—the 'extra group member' 'asks' students to meet task challenges, 'calls for' group discussions, and 'speeds up' group decision making; the students react in collaborative ways in order to 'answer' the 'extra group member'. The creative group ideas are the results of such

'conversations'. During such processes, individual motivation is stimulated and the group dynamic is strengthened, thereby facilitating deeper learning [40]. The interplay between individual creativity and group creativity also occurs in such processes.

There were some difficulties in dealing with technical work in our project. This was the basic reason that we always had meetings and discussions. The technical work really challenged us this semester. (P60, from Medialogy)

Sometimes our tasks in the project are not very clear, so we have to discuss. The project is always our focus in the group activities. But we are not always happy with the job—when we meet some big problems, we have to call for meetings and ask for help from supervisors or other experienced students. (P20, from Electronic System)

How can you identify whether an idea is creative or not? The easiest way is to examine the idea in practice. I mean, only when the ideas can make the system work, they are possible to be accepted by the group. But this also involves our discussion and negotiation until we make a good decision. (P53, from Medialogy)

Furthermore, the supervisors provide supportive facilitation in fostering creativity. As the students express in the interviews, the supervisors help them to deal with problems, such as the challenges of the project work and group disagreements. According to the observation data, most students have a good relationship with their supervisor, which is helpful in shaping a creative climate and increases the psychological safety of asking questions. However, the disadvantages found in this study indicate that more efforts on fostering creativity from teaching perspective should be made. For example, some students were found to have a poor conception of creativity, poor confidence in being creative and poor knowledge about creativity techniques. This means that, in the current AAU PBL model, there is a lack of an explicit way of teaching creativity along with the project process and, in particular, focuses on creativity knowledge in the curriculum. In project supervision, the *laissez-faire* exists. As the students in AAUSAT3 stated, they sometimes lose their way in the learning process due to the complexity of the project work, and therefore they need to be taught by being given knowledge directly instead of being asked open questions.

However, the supervisors thought that the best way to teaching creativity is to give the students enough space to explore answers to the questions. This means in the future, the relationships between the complexity of the project tasks, the students' responses, and ways of teaching should be paid more attention to at AAU. In addition, as the interviews show, students from different fields have a different understanding of creativity, which provides that the evidence of creativity is both

domain-general and domain-specific. So more negotiation of teaching creativity between different fields should also be taken into account in the future at AAU. For example, the following shows how the students from the Electronic System think 'creativity' is related to 'engineering', which means creativity is regarded as applying knowledge and theories in the problem-solving processes.

So both advantages and disadvantages of fostering creativity demonstrate the future systematic efforts that are required for building creative learning environments by PBL at AAU. They also indicate that the individualistic culture is the two sides of a coin in creativity development. It is supportive to the core philosophy of 'student-centred learning' of PBL, but it causes the *laissez-faire* in the project supervision. As Elisabeth and Ng [52] suggested, Western people put greater emphasis on open and democratic exchange if the ideas are between individuals. However, they are more loosely organized, with fewer social rules and norms and with less distinction between superiors and subordinates than Eastern people. Relating these points to a particular context of engineering education in China, the cross-cultural implications of fostering creative students will be illustrated in the following.

#### *4.2 Cross-cultural implications of fostering creativity by PBL in China*

Both academic research and educational policies support a growing attention to creativity development by PBL in China [10–12]. Considering the long tradition of the AAU PBL model and both its advantages and disadvantages in fostering creativity, can bring implications for China. The implications are mainly concerned with how to reconstruct relationships between teachers and students and between students. To break the barriers of the Confucian culture to creativity development in higher education is the condition of the new relationship construction required by PBL.

One of the most important lessons that China should learn from the AAU PBL model for creativity development is a good application of 'student-centred learning'. This means that students are expected to learn independently, actively and collaboratively; the teachers are expected to become expert learners who can face the complexity of learning together with the students. However, the respect for authority in China has deep connections with the rigid social stratification of the clan system in Chinese feudal society. Children are expected to comply with the requirements of adults without question. This is closely linked with 'filial piety', which requires absolute obedience and complete devotion to parents. The principle of total obedi-

ence to adults extended naturally from parents to teacher. So children are expected to respect the teacher's authority without preconditions. This stance clearly influences classroom activity where there is an emphasis on teaching, through lectures and demonstrations, rather than learning through discussion or pupil questions [47]. The authority and leadership of teachers have been regarded as the roots of barriers to group creativity development in the project context in higher education in China [10]. Thus, to establish the 'student-centred learning' approach required by PBL needs the restructuring of the traditional, teacher-directed teacher-student relationship influenced by the traditional culture of Confucianism.

In order to restructure the new teacher-student relationship required by PBL, the teachers have to change their roles from arranging learning tasks directly to facilitating the learning process in solving the open problems process. Therefore, they need to pick off the 'masks of authority of knowledge'. The open-mind learning cultures where the young students are motivated to become owners of learning are expected to build. Supervisors need to introduce creativity techniques into daily instruction. The appropriate techniques could be delivered during different phases of the student project work, which may increase the students' explicit understanding of creativity. Thus, a more comprehensive understanding of PBL and creativity must first be shaped among teachers. Only when educators pay more attention to creativity will the students have more opportunities to be creative in the learning process. So to facilitate staff, development on teaching creativity should be involved in the first stage in the process of institutional changes towards PBL. Some measures aimed at providing staff with knowledge about PBL, diverse methods by which to teach creativity should be implemented. Some measures of reforms in educational organizations in China should also be made in order to stimulate creativity and innovation. For example, to get rid of the elements of bureaucracy in organizations it is helpful to break the hierarchical structures and to realize the relatively equal relationships between the staff and between students and teachers.

The collectivistic values also influence the relationships between students in groups. As most of the Chinese students mainly depend on individual learning in the primary school and middle schools, group work is quite a new way of learning in PBL in higher education. According to the traditional thoughts of Confucianism, the purpose of education is to help people to develop ideal personalities—a Confucian gentleman is a person who consciously cultivates, practises, and displays his virtue [27]. But the increasing difficulties in employ-



ment after students' graduation from universities have rebuilt the purpose of education, which is to help the excellent students to find stable and high salary jobs. Thus, one of the goals of the students' learning is to gain higher scores than others in the examination. This means that when the university students are introduced to group work in PBL, competitive relationships between group members are barriers to idea sharing and exchange, group decisions, and sufficient communication, etc. Meanwhile, in the context of collectivism, the welfare of the group is seen as inseparable from that of the individual and conformity is emphasized. Adherence to group interests for the sake of achieving harmony is often justified at the expense of individual interests [27].

Accordingly, the supervisors also need to encourage diverse thinking in solving open questions when the groups are engaged in collective goals of project work. In other words, you should be aware of the interplay between individual creativity and group creativity—this should avoid having both dominant members and freeloaders in the groups, facilitate equal contributions from group members, encourage sufficient communication in peer learning and help to solve group disagreements effectively. To reform the traditional method of paper-pen student examinations and to build a new way of taking examinations, with emphasis on practical skills such as communication and collaboration, should also be taken into account.

In addition, when PBL is introduced to engineering education in China, the lessons that can be learned from the PBL model in the Danish context also include providing students with age-appropriate problems that challenge their thinking, paying attention to the relationships between the complexity of the project tasks and the students' responses, designing diverse PBL models in different educational fields, and being aware of the negotiation in teaching creativity between different fields, etc. This is similar to the suggestions for the future improvements of the AAU PBL model—systematic efforts are also required in the application of PBL in China.

## 5. Conclusions

This study sets a mirror for using PBL for creativity in engineering education between Denmark and China. From the discussions about both the advantages and the disadvantages of developing creativity by PBL in a Danish context, implications can be learned for the better use of PBL in engineering education in China. Therefore, from a cross-cultural perspective, suggestions are given to both contexts on the link of creativity, engineering education and PBL. However, any culture cannot com-

pensate for the needs for fostering the strongest creative personality. Only through a self-evaluation of their own culture, the elements that are blocking the populace, and the construction of more fertile creative soil can we lead the students to new levels of creative achievement [27]. So the future reflections also should be focused on how to learn from each other, between the different cultures, for improving educational methods and for developing creativity. In addition the discussions are only empirical data collected from a university in a Danish context by qualitative methods, although a number of participants were involved. This indicates the limitations of this study in the generalization of the conclusions. So in future, it is necessary to carry out a broader scope of investigation by multiple research methods, which will better fill in the current knowledge gap of creativity issues in cross-culture studies.

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