May problem-based learning get higher evaluation from student?

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Abstract

Purpose – The paper aims to explore the effect of problem-based learning (PBL) embedding degree and education level on individual perception, as well as the moderating effect of nationality.

Design/methodology/approach – The paper first conceptualizes PBL embedding degree which means the extent of applying PBL. It takes an empirical study on an international MBA class in one of the first-class universities in China. An investigation is taken with the designed "PBL-based Cognitive Perception Scale" and an Ordered Probit Model is constructed.

Findings – The findings of this study are as follows: PBL embedding degree has a significant effect on the cognitive perception of student, which varies in different dimensions; the educational level of international student positively affects the cognitive perception toward PBL; and nationality may moderate the relationship between the PBL embedding degree and individual perception.

Originality/value – The paper replenishes the investigation and application of Bloom's Taxonomy of Learning. By conceptualizing PBL embedding degree, the paper extends the research perspectives of PBL and

proposes a subjective method on the evaluation of PBL. The paper also may provide a guidance for PBL curriculum design with sustainable development of education.

Keywords Subjective perspective, Individual perception, PBL embedding degree, Problem-based learning (PBL)

Paper type Research paper

1. Introduction

The nature of education is cultivating student with a potential capability of autonomous growth, which leads heuristic teaching more crucial. Evolutionary education regards learning subject as a high developed self-organization system, with an innate tendency toward ordering. The development of learning subject is a process of autonomous evolution, in which, the inner motivation is the basic reason, while the quality change is the consequence. Therefore, the aim of education is helping student to develop and grow continuously. However, traditional university have adopted teaching process that simply transmit knowledge to student. With the development of society, it is necessary to rethink the roles of universities in 21st century and turn them into the foundation of economic progress and sustainable development. Universities need to adopt new and more effective teaching methods to improve student' learning ability instead of just transmitting knowledge to them. Teaching based on the competencies of sustainability presents a new challenge for university teacher, as well as an opportunity (Leicht *et al.*, 2018) for the evolution of the student autonomous learning ability.

Only through heuristic teaching can the autonomous evolution of student be achieved. Heuristic teaching involves an active academic engagement intending to enhance student' essential skills. Problem-based learning (PBL) is one of the important heuristic teaching methods, enlightening the evolution of student autonomous learning ability through the collaboration between student and lecturer, also among students. PBL offers a cycle of defining problem statement, independent study, group discussion and presentation of problem-solving proposal and reflection, with emphasis on the collaboration. PBL is a student-centered instructional model that contextualizes learning in an authentic problem-solving situation and has been extensively applied as an experimental teaching method in medical schools and certain technology courses during the past decades. Although considerable literature has verified that PBL can support important outcomes, such as the problem-solving skills and self-learning capabilities of student (Bergstrom *et al.*, 2016; Pease and Kuhn, 2011), research on its specific effects on perception remains controversial (Kirschner *et al.*, 2006; Strobel and Van Barneveld, 2009). Moreover, the practice of PBL is largely based on experience, and it is difficult to replicate existing PBL models into different contexts (Du, 2011). It is also important to know what extent of PBL in the teaching process, e.g. PBL embedding degree, is suitable for pursuing a sustainable and evolvable goal.

PBL has been widely applied internationally, whereas its rapid development in China has only occurred in the past 10 years. Do Chinese student have the same perception toward PBL as student in other countries? What affects the perception of Chinese student and international student toward PBL? Can PBL replace the traditional lecturer-centered teaching model? All these questions are still unresolved.

In addition, little research has focused on the multi-dimensional individual perception from individuals. And the evaluation from the internal subjective perspective of student is insufficient. Besides that, it rarely happens that student of different educational level take the same course, which means most research studies mainly focus on the scenario of student with the same educational level, and have no way to make a comparison.

Motivated to address the above limitations, our study focus on the effect of application extent of PBL on the individual perception of student. One cross-national MBA class in a

well-known university in China is chosen as a research context. For some reason, there were also some international undergraduates joined in the class during the semesters when the research was conducted, which offered us an opportunity to observe their perception. Students were invited to express and scale their internal subjective perception of multi-dimension. The target of evaluation was composed of different teaching topics which had different application extent of PBL. The students had varying demographic characteristics, for example, nationality, age, gender, educational level and work experience. The research questions addressed in this study are as follows:

RQ1. How does PBL embedding degree affect the individual perception toward PBL?

RQ2. How does nationality of student affect his/her individual perception toward PBL?

RQ3. How does the educational level of student affect the individual perception toward PBL?

2. Related literature
As for PBL, a teaching and learning method that emphasizes the participation and the collaboration, scholars have carried considerable research, mainly focusing on several aspects, such as, the design and evaluation of PBL, the comparison between PBL and the traditional teaching model, cross-national applicability of PBL.

2.1 Design and evaluation of problem-based learning
On the topic of design and evaluation of PBL, scholars have put increasing emphasis on the diversity of assessment measures and performances of student (Boud, 2006). For instance, five elements of PBL has been defined (Johnson *et al.*, 1998), and the strategic process of PBL has been clarified (Hmelo-Silver and Barrows, 2006; Schmidt, 2010). At the same time, some studies have proposed the key factors that affect the effects of PBL. For instance, active student engagement is key to the success of PBL; hence, (non-) attendance matters for several measures of study success and also for the committed and participating student (Bijsmans and Schakel, 2018). Sockalingam *et al.* (2011) have assessed the effectiveness of problems in PBL. Meanwhile, PBL shows its power for sustainable education. PBL can successfully participative learning, critical reflection, systemic thinking, creativity and cultural awareness, which simultaneously are the core values of educational sustainability (Du *et al.*, 2013) and PBL can be an innovative pedagogy for sustainability education (Lehmann *et al.*, 2008). However, some scholars have argued that PBL assessment should consider not only the knowledge outcomes of student but also the combination of its theoretical goals (Hmelo *et al.*, 1997).

2.2 Comparison between problem-based learning and the traditional teaching model
In terms of comparison on PBL and traditional lecture-based model, most scholars hold a positive attitude. They believe that the learning effect of PBL is superior to that of the traditional teaching model. The advantage of PBL is that students become more aware of how they can put the knowledge that they are acquiring to use (Hallinger and Lu, 2011). PBL is intended to enhance learning skills by engaging student through self-direction and problem-solving and also to nurture teamwork and communication skills, while traditional teaching methods mainly involve transmitting knowledge from the teacher to the student and is very much teacher-centered. For instance, Severiens and Schmidt (2009) have compared effects of a full-fledged PBL environment with effects of a conventional lecture-

based learning environment and a learning environment that combines lectures and other methods aimed at activating student, find that student in a PBL environment showed higher levels of academic and social integration. Moreover, Aragão, Freire *et al.* (2018) have found that although there is a higher frequency of depression among medical students who followed the PBL, they have higher satisfaction and fulfilment of expectations with the activities that they have developed during the course. In addition, PBL also has favorable effects on improving the critical thinking, second language acquisition, Web-based English reading skill and ability acquisition beyond knowledge of student (Blandin *et al.*, 2014; Chen, 2013; Li, 2018; Lin, 2017; Zhu, 2016). Beyond knowledge building and skill acquirement, PBL contributes to broadening learners perspectives and promoting their personal development (Takahashi and Saito, 2013). From the perspectives of teacher, the considerable time needed for preparing for PBL teaching can be compensated by the benefits of clinical practices (Doherty *et al.*, 2018).

However, the cognitive benefits brought by PBL are still controversial. Some studies have shown that the PBL cannot bring better effects than traditional learning methods, or at least it does not make significant difference in all aspects (Choi *et al.*, 2014). For instance, students in PBL obtain lower scores than those in traditional teaching model in terms of grasping fundamental knowledge (Albanese and Mitchell, 1993). A study has shown that PBL has positive effects for skills, but non-robust effects for knowledge (Dochy *et al.*, 2003). Moreover, students in PBL prefer to use a backward-directed pattern of reasoning compared with the traditional teaching model. Thus, they have a greater tendency to commit errors (Patel *et al.*, 1993) and have lower academic abilities (Mergendoller *et al.*, 2000). The belongingness and academic success in two commonly applied types of learning environments: learning communities (LCs) and PBL are investigated. Belongingness appears more important in LCs, whereas for PBL, formal peer interaction seems more important for academic success. LCs are dominantly focused on creating a safe environment, whereas a PBL context is mainly focused on knowledge construction (Brouwer *et al.*, 2019).

2.3 Cross-national application of problem-based learning

Some studies have noticed that the effectiveness of PBL varies across nationality. Significant differences have been found between nationality with respect to learning behaviour and goal orientation in PBL environment (Geitz *et al.*, 2016). PBL environment can be challenging for students whose language backgrounds are different from that of the classroom (Woodward-Kron and Remedios, 2007). Frambach *et al.* (2012) have investigated what happens after PBL is applied in three medical schools in different countries: East Asia, the Middle East and Western Europe. The uncertainty and tradition pose a challenge to the PBL of Middle Eastern student, whereas hierarchy poses a challenge to Asian student. In addition, gaining a sense of achievement effects both sets of non-Western student. Singaram *et al.* (2011) have explored the key advantages and problems of student from diverse backgrounds collaborate which each other when learning in PBL groups. From these results, it can be determined that student of different nationality may have different individual perception toward PBL.

2.4 Literature review

Basing on the above, scholars have carried out substantial meaningful research, however, certain aspects of the study must be examined further.

The enhancement effect of teaching is broadly measured by the performance or outcome, such as achievement, cooperation, innovation and practical problem-solving skills. However, little research has focused on the multi-dimensional individual perception from individuals.

The existing literature has mostly adopted the external objective method to evaluate the effectiveness of PBL. Although a couple of studies have looked into the perception of student toward PBL, these studies have mainly focused on the perception concerning the motivational aspects of the assessment tasks. Consequently, the evaluation from the internal subjective perspective of student is insufficient.

3. Methodology

3.1 Theoretical basis

Bloom's Taxonomy of Learning is applied to serve as the fundamental theory. Bloom views education as a process of objective and evaluation. According to Bloom's Taxonomy of Learning, there are three domains of educational activities or learning, that can enhance student's learning skills (Bloom *et al.*, 1956). These three domains are cognitive, affective and psychomotor. And there are further categories for the three domains. Six categories are involved within the cognitive domain, which are knowledge, comprehension, application, analysis, synthesis and evaluation. Lorin Anderson, a former student of Bloom, revisited the cognitive domain with perhaps the three most prominent ones being, changing the names in the six categories from noun to verb forms, e.g. remembering, understanding, applying, analyzing, evaluating and creating (Anderson *et al.*, 2001).

Bloom's Taxonomy of Learning and revised one emphasis the education design from the perspective of teacher, whereas, the individual perception toward the education design from the perspective of student also need to be investigated. Therefore, we compare the three taxonomies with more adequate terms from five dimensions, aiming at solving the research questions stated above. Correspondingly, cognitive is described with the dimension of understanding in the subject, affective with the dimensions of cultivating interest in the subject, and enjoyment in doing the activity, while psychomotor with the dimensions of more participation, and ability improvement in solving problems. The parallelism of Bloom's Taxonomy of Learning from the perspective of teacher and the individual perception from the perspective of student is shown as Figure 1.

3.2 Research framework

The paper conceptualizes the PBL embedding degree as the core term in the paper and defined it as the extent of applying PBL in different teaching topics, illustrated by percentage. The PBL embedding degree of each topic may be different. Which means, if the lecturer applies more independent study, more group discussion, more presentation of problem-solving proposal and more reflection etc. in one topic, the PBL embedding degree of this topic will be higher, vice versa. Its number may be defined by the lecturer according to his/her own experience. In this study, PBL embedding degree with 0% meant completely adopting the traditional lecturer-centered learning, whereas PBL embedding degree with 100% represented completely adopting the PBL and 50% meant half. The topic with 0% PBL embedding degree is selected as the control group, whereas the other topics are regarded in the experimental group. Therefore, not only the influence of PBL and traditional teaching methods on student' perception toward PBL is compared, but also the PBL with different embedding degree on student' perception toward PBL is analyzed.

The individual perception is conceptualized as another core term in the paper. It is defined as student' perception toward PBL, which describes student' perception about their gains and outcome from the course. In the paper, individual perception is measured from different dimensions.

Students in a cross-national MBA class who take a certain course are taken as the research object. "IMBA Students Individual Perception Scale" is designed on the basis of

PBL to collect demographic information about the participants and evaluate their individual perception. The main purpose is to analyze the effect of PBL embedding degree on student' subjective individual perception, which is reflected by student self-report data. Besides that, as a certain number of international undergraduates joined the course, the paper also tried to look into the comparison of international student in different educational levels. Furthermore, the paper examines whether the nationality and PBL embedding degree jointly affected the individual perception of student. Age, gender, and work experience were selected as control variables. Figure 2 shows the research framework.
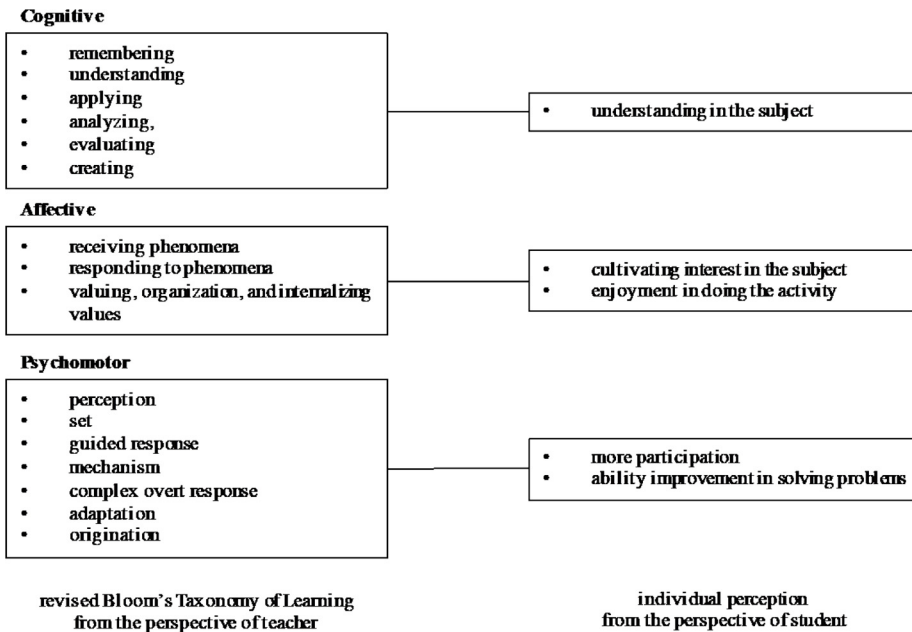

Figure 1.
Parallelism of revised
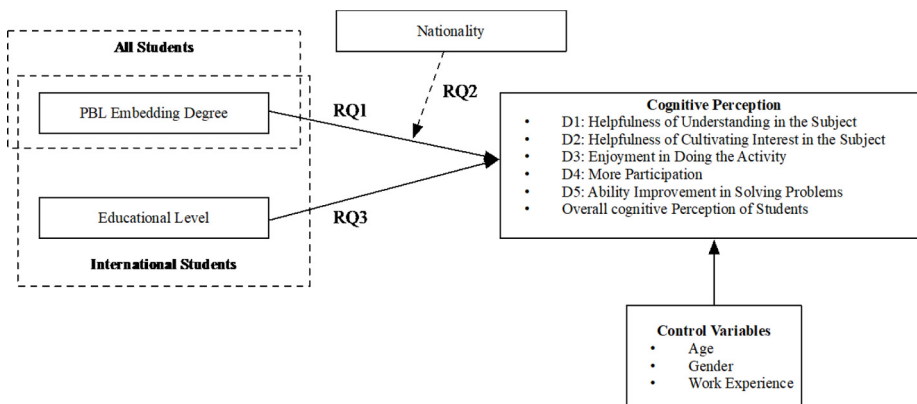Bloom's Taxonomy
of Learning and
individual perception

Figure 2.
Research framework

3.3 Context

The course of Management Information System (MIS) is chosen as the research scenario. PBL is implemented in this course to train student to synthesize knowledge of MIS, while enhancing their knowledge through application of knowledge of MIS in the real world. Compared with the former studies using examination scores to verify the effectiveness of PBL on learning outcomes, the paper focused on the enhancement and experience of the internal individual perception of student.

Following the criteria for PBL curriculum (Dobson and Bland Tomkinson, 2012), the course is designed into eight topics, seven of which were topics designed by the lecturer with different PBL embedding degree. We interviewed several experience lecturers who have engaged the course (MIS) teaching for many years to give their idea for the numbers of different class activities and learning modules, according to the emphasis of PBL in each part. Basing on that, we calculated the PBL embedding degree for different teaching topics. the PBL embedding degree of each topic are as follows: IS Strategy in Organization (30%, mainly lecturing except the discussion on the Porter's Five Forces Model in a special business), Mainstream IS Application and Data Modelling (40%, both introducing of IS applications and exercising on data modelling under a video-selling case), Advanced Information System Applications (20 %, mainly lecturing except a short group discussion on Google), Introduction of Artificial Intelligence (0%, all lecturing by a visiting professor), SAP GBI System Practice (80%, mainly exercising on SAP platform to fulfil an entire business process, with the help of lecturer), E-Commerce Case Debate (70%, mainly debate on the given issue, with a certain guidance from lecturer), System Development Processes and Methods (10%, almost all lecturing, with a small part of reading) and IS Related Business Plan Presentation and Investment Allocation Competition (90%, almost all presentation and competition, with a small part of guidance from lecturer). Correspondingly, the topic, Introduction of Artificial Intelligence, given by a visiting professor, adopted the traditional lecturer-centered learning model (the PBL embedding degree was 0%, completely dominated by the lecturer).

The topic, Introduction of Artificial Intelligence, on the other hand, is selected as the control group given that its PBL embedding degree was 0%, whereas the other seven topics were in the experimental group. Drawing on the Student' Learning Experience Scale (Alwi and Hussin, 2018) and student self-evaluation rating approach (Kricsfalusy *et al.*, 2018), individual perception is divided into five dimensions: helpfulness of understanding in the subject, helpfulness of cultivating interest in the subject, enjoyment in doing the activity, more participation and ability improvement in solving problems.

3.4 Data

In the study, the research objects are the students from cross-national MBA (IMBA) classes in Beijing Institute of Technology, one of the first-class universities in China. Total 151 students enrolled in the years of 2018 and 2019 were conducted investigations separately. The class of IMBA 2018 comprised of 79 mixed-nationality students, 44 from China, while 35 from Europe, North America, South America and other Asian countries. And the class of IMBA 2019 comprised 72 mixed-nationality students, 35 from China, while 37 from other countries. Among the international students, some were exchange undergraduates, some were exchange postgraduates, while some were official international MBA students. As Jansen *et al*. (2017) has shown, such a diverse and cross-national student body creates additional challenges as far as academic and social integration is concerned.

"IMBA Students Individual Perception Scale" is composed of two parts. The first part collected demographic information about the participants, including the nationality, age,

gender, work experience and educational level. In the second part, each student was asked to rate eight teaching topics (range from −2, −1, 0,1 to 2: −2 means the least likely, and 2 means the most likely) with different PBL embedding degree on five individual perception dimensions, which were the contents they believed the topic had helped them. At the end of the course, every student in the class was asked to finish the questionnaire on an online survey platform. The questionnaire can only be submitted when all eight topics have been completed. A total of 145 (78 of 79 from IMBA 2018, and 67 of 72 from IMBA 2019) questionnaires were returned. Questionnaires with over 100 s fill-in time were kept, leaving 132 questionnaires in the final selection. Stata software was applied to process and analyze the data.

3.5 Variable definitions
3.5.1 Dependent variables. To measure the individual perception of student toward PBL, the dependent variables was described from five dimensions, which were *HelpUnder*, *HelpCult*, *EnjoyDo*, *MoreParti* and *AbiSolv*. *HelpUnder* refers to helpfulness of understanding in the subject, *HelpCult* refers to helpfulness of cultivating interest in the subject, *EnjoyDo* refers to enjoyment in doing the activity, *MoreParti* refers to more participation, and *AbiSolv* refers to ability improvement in solving problems.

Besides that, for getting a whole individual perception of student toward PBL, a composite variable, *CogniPercep*, was defined, which was the sum of the above five dependent variables. Factor analysis was conducted on these five dimensions. used Kaiser–Meyer–Olkin (KMO) Test was taken to measure these dimensions. The KMO values were all greater than 0.8, which meant the five dimensions was suitable for factor analysis. After the initial survey refinement, a pilot test was conducted to ensure that the instrument had acceptable reliability and validity. Cronbach's alpha coefficient of reliability statistics was 0.887, and that based on the standardized terms was 0.888, indicating that the questionnaire had high inherent heterogeneity and strong reliability.

3.5.2 Independent variables. Three independent variables were constructed. The primary independent variable of interest was *EmbeDegree*, referring the PBL embedding degree of each teaching topic. The other two independent variables were Nationality, referring the nationality of student, whereas *Edulevel*, indicating student' educational level.

3.5.3 Control variables. Age, Gender and Work were chosen as the control variables which referred to age, gender and years of work experience separately.

Table 1 shows the summary statistics of variables.

To avoid multicollinearity between independent variables, the variance inflation factor (VIF) of each variable were tested. The results are shown in Table 2. As the maximum value of VIF was 3.73, much less than 10, thus no need to worry about multicollinearity.

4. Empirical study and results
4.1 Impact of problem-based learning embedding degree on the individual perception of student
The Ordered Probit Model was applied to explore the effect of the PBL embedding degree on the individual perception of student. The base model is as follows.

$$y_{ij} = \alpha_i + \beta_1 EmbeDegree_i + \beta_2 Work_i + \beta_3 Gender_i + \beta_4 Age_i + \varepsilon_i, \tag{1}$$

where y_{ij} refers to the individual perception of student i in perception dimension j. $EmbeDegree_i$ denotes the PBL embedding degree in different teaching topics, $Work_i$ refers to the years of student i's working experiences, $Gender_i$ indicates the gender of student i, Age_i

Variable	Definition of variables	Mean	SD
Dependent Variables (Individual perception from fivedimensions)			
HelpUnder	helpfulness of understanding in the subject, from −2 to 2. −2: Unlikely, 2: Likely	1.19	0.85
HelpCult	helpfulness of cultivating interest in the subject, from −2 to 2. −2: Unlikely, 2: Likely	1.08	0.90
EnjoyDo	enjoyment in doing the activity, from −2 to 2. −2: Unlikely, 2: Likely	1.01	0.96
MoreParti	more participation, from −2 to 2. −2: Unlikely, 2: Likely	0.96	0.98
AbiSolv	ability improvement in solving problems, from −2 to 2. −2: Unlikely, 2: Likely	0.92	0.97
CogniPercep	whole individual perception of student toward PBL	5.16	3.87
Independent Variables			
EmbeDegree	PBL embedding degree in different teaching topics (0%–100%)	0.425	0.315
Edulevel	1: Postgraduate, 0: Undergraduate	0.88	0.33
Moderating Variable			
Nationality	1: Chinese, 0: Internationals	0.56	0.50
Control Variables			
Gender	1: Male, 0: Female	0.44	0.50
Age	1: Under 25, 2: 26∼30, 3:31∼40, 4: Above 40	2.05	0.88
Work	1: None, 2: 1∼3years, 3: 3∼5years, 4: 6∼10years, 5:11∼15years, 6: Above 15 years	3.20	1.43

Table 1.
Variables definition and description

Variable	VIF	1/VIF
EmbeDegree	1.00	1.000
Edulevel	1.28	0.779
Gender	1.02	0.976
Age	3.72	0.269
Work	3.73	0.268

Table 2.
Results of VIF

stands for the age of student i, and ε_i denotes the model error term. In Models 1– 6 of Table 3, the five different dimensions of individual perception and the whole individual perception as explained variables were taken separately.

In Table 3, Models 1–5 represented five dimensions, and student' individual perception of each dimension is different. After controlling the variables of gender, age and work experience, the paper found, the PBL embedding degree had positive effects on the individual perception of student and that on "more participation" and "ability improvement in solving problems" at the 1% and 5% significance levels (Models 4–5), respectively. As PBL combined learning with tasks or problems to engage the learners in the context, the change in the PBL embedding degree was more likely to affect the individual perception of student that are more closely related to physical skills, including the fourth dimension "more participation," and the fifth dimension "ability improvement in solving problems." The results show that PBL can enhance and leverage student' competencies and skill-sets (Taylor, 2017). When the embedding degree of PBL was improved, student were more likely to participate in the class and improve their ability in solving problems. Moreover, the

Variables	Model 1 *HelpUnder*	Model 2 *HelpCult*	Model 3 *EnjoyDo*	Model 4 *MoreParti*	Model 5 *AbiSolv*	Model 6 *CogniPercep*
$EmbeDegree_i$	−0.002 (−0.02)	0.082 (0.77)	0.135 (1.26)	0.594*** (5.52)	0.215** (2.03)	0.254** (2.53)
$Gender_i$	−0.008 (−0.11)	−0.060 (−0.83)	−0.181** (−2.50)	−0.188** (−2.61)	0.108 (−1.50)	−0.136* (−2.00)
Age dummies	YES	YES	YES	YES	YES	YES
Work dummies	YES	YES	YES	YES	YES	YES
Observations	1056	1056	1056	1056	1056	1056

Notes: Robust standard errors are displayed in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 3.
Results of base
models

results have shown that PBL embedding degree has no significant effect on the individual perception on "helpfulness of understanding in the subject," "helpfulness of cultivating interest in the subject," and "enjoyment in doing the activity" (Models 1–3). Compared with traditional teaching model, PBL student may not have adequate exposure to a range of content (Albanese and Mitchell, 1993), so it would not have a significant impact on understanding and enjoyment in the subject. In Model 6, the PBL embedding degree positively affected the whole individual perception of student. It suggested that PBL teaching effect was better than traditional teaching methods in management courses. The results may provide a reference for teacher to adjust the PBL embedding degree in the curriculum to better play the role of PBL.

4.2 Moderation effect of nationality
The analysis above considered the impact of PBL embedding degree on the individual perception of student. The paper also wants to discovery whether the nationality of student may moderate the relations between PBL embedding degree and the individual perception of student. Therefore, the interaction term of the nationality with PBL embedding degree ($Nationality_i \times EmbeDegree_i$) was added into the base model.

$$y_{ij} = \alpha_i + \beta_1 EmbeDegree_i + \beta_2 Nationality_i + \beta_3 EmbeDegree_i * Nationality_i + \beta_4 Work_i$$
$$+ \beta_5 Gender_i + \beta_6 Age_i + \varepsilon_i.$$

(2)

As it can be seen from Table 4, the nationality may influence the effect of PBL embedding degree on the individual perception of student on the dimension of "enjoyment in doing the activity." The increase of the PBL embedding degree could more positively affect the enjoyment of Chinese students than Internationals. This result was similar to the finding of Frambach *et al.* (2012), which has presented the perception effect of PBL among students varied with nationality. However, according to Frambach's study, students from Western countries adapted better to PBL, which was slightly dissimilar from our results. There were significant differences between Chinese and international students in enjoyment in doing PBL-related activities, while no significant differences in other aspects.

5. Robustness check and additional analysis
5.1 Independent variable replacement
To examine the robustness of these results, the whole individual perception of student (Model 6 in Table 4) was taken as an example for further study. As the independent variables had different effects on the individual perception of student in each dimension, the use of whole individual perception as a variable was more representative.

The control variables were added gradually to check the regression result, as follows:

$$\text{Model I}: \ y_i = \beta_0 + \beta_1 EmbeDegree_i + \varepsilon_i,$$

(3)

$$\text{Model II}: \ y_i = \beta_0 + \beta_1 EmbeDegree_i + \beta_2 Gender_i + \varepsilon_i,$$

(4)

$$\text{Model III}: \ y_i = \beta_0 + \beta_1 EmbeDegree_i + \beta_2 Gender_i + \beta_3 Age_i + \varepsilon_i,$$

(5)

Variables	Model 1 HelpUnder	Model 2 HelpCult	Model 3 EnjoyDo	Model 4 MoreParti	Model 5 AbiSolv	Model 6 CogniPercep
$Nationality_i$	0.125 (0.71)	0.253 (1.46)	0.055 (0.32)	0.206 (1.19)	0.253 (1.48)	0.249 (1.54)
$EmbeDegree_i$	−0.091 (−0.56)	0.032 (0.20)	−0.122 (−0.77)	0.487*** (3.05)	0.200 (1.26)	0.140 (0.93)
$Nationality_i$ * $EmbeDegree_i$	0.164 (0.75)	0.096 (0.45)	0.469** (2.19)	0.197 (0.92)	0.028 (0.13)	0.208 (1.04)
$Gender_i$	−0.001 (−0.02)	−0.051 (−0.70)	−0.173** (−2.39)	−0.179** (−2.47)	−0.100 (−1.39)	−0.126* (−1.86)
Age dummies	YES	YES	YES	YES	YES	YES
Work dummies	YES	YES	YES	YES	YES	YES
Observations	1056	1056	1056	1056	1056	1056

Notes: Robust standard errors are displayed in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 4.
Results considering
the moderation effect
of nationality

$$\text{Model IV: } y_i = \beta_0 + \beta_1 EmbeDegree_i + \beta_2 Gender_i + \beta_3 Age_i + \beta_4 Work_i + \varepsilon_i. \tag{6}$$

Model I aimed to explore the impacts of the PBL embedding degree on the individual perception of student. Meanwhile, Models II, III and IV (just the base model) drew gender, age and work into Model I as control variables, respectively.

Table 5 shows the regression results of the above four models. These estimates were similar to the main results and showed that the PBL embedding degree still had positive effects on the individual perception of student. The dependent variables of the five dimensions were also examined, and the results in the five dimensions were robust.

5.2 Ordinary least squares regression

We also used the Ordinary Least Squares Regression Model(OLS Model) to confirm the impact of the treatments. Results are reported in Table 6. In Model 5, we report the moderation effect of nationality on the dimension of "enjoyment in doing the activity." The coefficient of $Nationality_i \times EmbeDegree_i$ is 0.385 and is statistically significant at the $p < 0.05$ level. It is consistent with the result in Section 4.2. Further, we still took the whole individual perception of student as the example for further study. We set up four models (Models 1–4) similar to those in Section 4.3. The results were robust.

5.3 Additional analysis: considering the impact of educational level of international student

The comparison of individual perception with different educational levels also captures interest. Targeting to the subset of international students, which included both postgraduates and undergraduates, *Edulevel*, an independent variable indicating student' educational level, was added to study its effect on the individual perception of student. The following model was established.

$$y_{ij} = \alpha_i + \beta_1 EmbeDegree_i + \beta_2 Edulevel_i + \beta_3 Gender_i + \beta_4 Age_i + \varepsilon_i, \tag{7}$$

Variables	Model I	Model II	Model III	Model IV
$EmbeDegree_i$	0.248** (2.48)	0.249** (2.49)	0.250** (2.50)	0.254* (2.53)
$Gender_i$		−0.184*** (−2.91)	−0.145** (−2.24)	−0.136* (−2.00)
Age_i				
AgeDummy1			0.532** (2.06)	0.508 (1.45)
AgeDummy2			0.729*** (2.81)	0.533 (1.57)
AgeDummy3			0.714*** (2.77)	0.484 (1.56)
$Work_i$				
WorkDummy1				−0.090 (−0.81)
WorkDummy2				0.133 (1.00)
WorkDummy3				0.452*** (2.65)
WorkDummy4				0.031 (0.16)
WorkDummy5				−0.070 (−0.28)
Observations	1,056	1,056	1,056	1,056

Table 5.
Regression results of the whole individual perception of student

Notes: Robust standard errors are displayed in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

where all of the variables were exactly the same as shown in equation (1). An independent variable $Edulevel_i$, denoted the educational level of student was added.

The results are shown in Table 7. Although the undergraduate and postgraduate students took the same courses, they had different physical skills, such as understanding of knowledge, due to their different educational level. The educational level of international student had significant impacts on "helpfulness of understanding in the subject," "helpfulness of cultivating interest in the subject," and the whole individual perception of student. However, whether undergraduate or postgraduate student, there was no significant difference in their individual perception of the other three dimensions.

Compared with the main analysis, the significance of PBL embedding degree had changed in Model 5. In this additional analysis, the research objectives were international students. The PBL embedding degree had no significant effect on international students' ability in solving problems. However, the influence of PBL embedding degree on the individual perception "more participation" was still significant.

The method of examining the robustness of the results was similar to Section 6. Equation (7) was decomposed into three models, and control variables were gradually added for regression. The results showed that the significance of the PBL embedding degree and the educational level did not change in the five dimensions. Therefore, the results were also robust.

6. Discussion

Based on the results from each RQ summarized in Figure 3, we can further discuss our findings in terms of theory and practice.

- PBL embedding degree affects the individual perception of student toward PBL, and the effects are divergent in different dimensions. Meanwhile, the three taxonomies in Bloom's Taxonomy of Learning (Anderson et al., 2001; Bloom et al., 1956) may have different outcome from the perspective of student. As PBL combined learning with tasks or problems to engage the learners in the context, the change in the PBL embedding degree was more likely to affect the individual perception of student that are more closely related to physical skills, such as "more participation" and "ability improvement in solving problems." When the embedding degree of PBL was improved, student were more likely to participate in the class

Variables	Model 1 Only $EmbeDegree_i$	Model 2 $EmbeDegree_i +$ $Gender_i$	Model 3 $EmbeDegree_i +$ $Gender_i + Age$ dummies	Model 4 Base Model	Model 5 Moderation Effect of Nationality ($EnjoyDo$)
$Nationality_i$					0.078 (0.52)
$EmbeDegree_i$	0.661* (1.68)	0.661* (1.68)	0.661* (1.69)	0.661* (1.70)	−0.157 (−1.04)
$Nationality_i *$ $EmbeDegree_i$					0.385** (1.97)
$Gender_i$		−0.663*** (−2.75)	−0.533** (−2.18)	−0.508** (−2.07)	−0.162** (−2.54)
Age dummies	NO	NO	YES	YES	YES
Work dummies	NO	NO	NO	YES	YES
Observations	1056	1056	1056	1056	1056

Notes: Robust standard errors are displayed in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 6.
Results of the ordinary least squares regression

Table 7.
Results the international student' individual perception

Variables	Model 1 HelpUnder	Model 2 HelpCult	Model 3 EnjoyDo	Model 4 MoreParti	Model 5 AbiSolv	Model 6 CogniPercep
$EmbeDegree_i$	−0.088 (−0.54)	0.030 (0.19)	−0.115 (−0.72)	0.486*** (3.04)	0.195 (1.23)	0.171 (1.14)
$Edulevel_i$	0.230* (1.87)	0.254** (2.08)	0.145 (1.20)	0.133 (1.10)	0.124 (1.02)	0.225* (1.96)
$Gender_i$	−0.175* (−1.67)	−0.167 (−1.61)	−0.295*** (−2.85)	−0.398*** (−3.82)	−0.346*** (−3.33)	−0.339*** (−3.47)
Age dummies	YES	YES	YES	YES	YES	YES
Observations	464	464	464	464	464	464

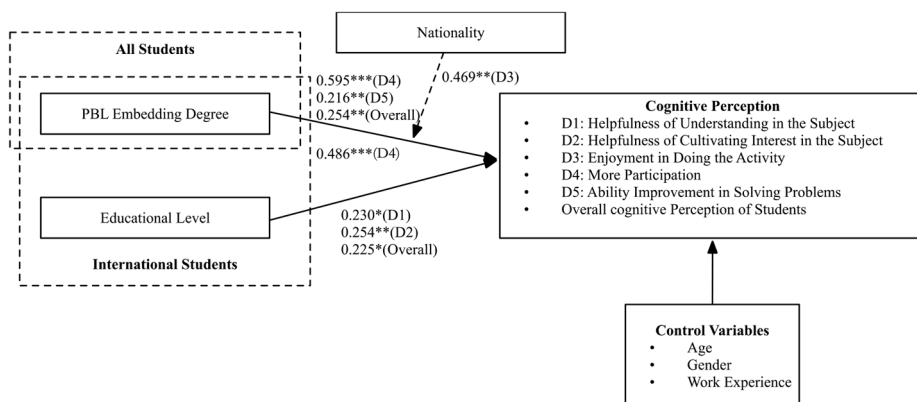**Notes:** Robust standard errors are displayed in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Figure 3.
Main results

and improve their ability in solving problems, which are important for student to improve their sustainable practicing and exploring abilities in the lifelong study. This discovery may offer a guidance for lectures to apply PBL to the adequate topics with more practical meaning. It has no significant effect on the individual perception that are related to emotional improvement, such as "helpfulness of understanding in the subject," "helpfulness of cultivating interest in the subject," and "enjoyment in doing the activity." The improvement of PBL embedding degree cannot significantly change student' emotional aspects. Lectures need to combine PBL with other teaching methods to mobilize student' emotional involvement to a greater extent.

- Nationality may moderate the relationship between the PBL embedding degree and individual perception. Compared with that for international student, PBL for Chinese student can positively promote the individual perception of student on the dimension of "enjoyment in doing the activity," but no significant moderation effect on the overall individual perception. This might give a certain of explanation of the idea that student of different nationality may have different individual perception toward PBL, which is shown in the study of Frambach *et al.* (2012) and Singaram *et al.* (2011). Basing on this result, lectures can apply more PBL teaching method for Chinese student, if it is possible, in order to reach the target of sustainable involvement in class activity.

- Educational level of international student exhibits positive effects on student' individual perception, including the dimension of "helpfulness of understanding in the subject" and "helpfulness of cultivating interest in the subject." This means that postgraduates more value about the deeper meaning and understanding of the subject, whereas undergraduates more value about the practical and physical aspect of the subject. However, this finding is different in terms of education level, with the result of (Arseven *et al.*, 2016), which shows that the effect gradually decreases from primary school to high school. This divergence might come from the subdivision of effect in this study. Basing on this result, lectures can design different teaching model for different educational level of international student, to maximize the long-term outcome after class.

7. Conclusion

7.1 Theoretical implication

- In spite of Bloom's Taxonomy of Learning offers an education guidance to teacher, the paper focuses on the outcome of Bloom's Taxonomy of Learning from the perspective of student. The outcome is measured from five dimensions, including physical skills and motion improvements, replenishing the investigation and application of Bloom's Taxonomy of Learning.

- Most existing literature have focus on comparing PBL to the traditional teaching model and exploring the enhancement effect of PBL. This paper is the first to propose the concept of PBL embedding degree, trying to compare the effect of full PBL and part PBL, thereby extending the research perspectives of PBL.

- Previous studies have mostly used external and objective evaluation methods (e.g., test scores) to measure the enhancement effect of PBL. The paper has conducted the research to examine the individual perception on various teaching topics with different PBL embedding degree from the internal perspectives, proposing a subjective method on the evaluation of PBL.

7.2 Practical implication

- The effect of PBL based on different educational level of student are evaluated, providing new evidence for the impact of student heterogeneity on education for sustainable development.

- The result of the paper may illustrate a reasonable way to improve the quality of class teaching process, maximizing the impact of PBL and getting a further, meaningful achievement toward the collaboration and educational sustainability.

- Basing on the different effect of PBL embedding degree, nationality and education level, the paper provides a guidance for PBL curriculum design with sustainable development of education.

7.3 Study limitation

Our study has certain limitations that deserve further discussion. First, in our research, one of the eight teaching topics that adopts the traditional teaching model is taken as the control group, while the other seven teaching topics are treated as the experimental groups. However, the selection of the topics and the course may have some influence on the results. In future studies, various topics can be randomly selected as the control group in different courses. The influence of this interference term can be reduced through repeated experiments.

Second, the number of samples in this study is limited, only 134 valid questionnaires were collected from two cross-national IMBA classes of two years. In future studies, the same research paradigm can be applied to collect more student samples in different courses and years. Regarding both the panel dada and pooled cross-sectional data, the research results may be closer to the conditions in the real world and may lead to further interesting results.

Third, the number of PBL embedding degree of different topic in the paper is proposed by the lecturer of the course (also one of the authors) according to the numbers of different

class activities and the numbers of learning modules, which deserve further discussion and validation.

During the education process of PBL, the inner motivation and the outer cultivation work together. With respecting the individual perception and crowd collaboration, PBL will improve the inherent capacity of learning subject for growth, development and autonomous evolution.

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