Chinese teachers' views on implementing problem-based learning in the Chinese mathematics classroom

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Problem-based learning (PBL) is an important form of student-centred pedagogy that departs from the conventional form of teacher-centred pedagogy often reported in Chinese classrooms, and so there is a need to understand how Chinese teachers perceive PBL. This study used a case study methodology and in-depth focus group discussions with 6 teachers from three Chinese secondary schools to investigate Chinese teachers' views on the implementation of PBL in Chinese mathematics classrooms. The findings indicated that PBL was relatively accepted by the participants, who believed that PBL could improve students' problem-solving skills and interest in mathematics. However, participants considered that exclusively using PBL would not be ideal, and they advocated combining PBL with conventional teaching (CT) for the best learning outcomes. Implications for research and practice are discussed in light of these findings.

Keywords: Problem-based learning (PBL); student-centred pedagogy; teacher-centred pedagogy; Chinese mathematics education

Introduction

High achievement in mathematics competitions but low attitudes toward mathematics (Mullis et al., 2020), and a lack of mathematical problem-solving skills when solving interactive, open-ended mathematics problems, are still common issues among Chinese students (Cao et al., 2017; OECD, 2014). These issues may be due to Chinese secondary schools primarily using conventional teaching (CT) in the form of teacher-centred pedagogy that is focused on information transmission and algorithms, which may compromise students' learning interest and their problem-solving skills (McCarthy & Anderson, 2000). Problem-based learning (PBL), a student-centred, group cooperative approach whose benefits on mathematical interests and performance have been discussed by many researchers (e.g., Kazemi & Ghoraishi, 2012； Ridlon, 2009), could be a potential solution for addressing these issues.

However, such a student-centred pedagogy might be difficult to implement in Chinese schools as Chinese teachers, who play a pivotal role in Chinese education, face immense pressure to prepare their students for high-school and college entrance examinations. As a result, these teachers might not see adopting PBL as a necessity or even as a possibility within the time constraints of a busy curriculum. Given the scarcity of research on how Chinese teachers perceive PBL, this study aimed to deepen the field's understanding of Chinese teachers' views on implementing PBL in the context of an examination-driven society.

Literature review

Definition and effect of PBL

PBL was proposed by Barrows and Tamblyn at McMaster University in 1960 to promote learning by enabling students to see the relevance and application to medicine and future careers (Barrows & Tamblyn, 1980). It often contains the following six features: (1) learning is student-centred; (2) learning occurs in small groups; (3) teachers are facilitators rather than instructors; (4) problems are stimuli for learning; (5) problems are real-world related; (6) new information is acquired through self-directed learning (Barrows, 1996).

PBL was reported to enhance mathematical interest, confidence and problem-solving skills (e.g., Kazemi & Ghoraishi, 2012). The real-world aspect of problems in PBL is essential to students' interest development in mathematics (Kazemi & Ghoraishi, 2012). However, this real-world aspect – feature No.5 of PBL – was overlooked and neglected in mathematics learning by many researchers (e.g., Ridlon, 2009; Savery, 2015). This might be due to the reasoning that such a real-world feature is not as necessary in the field of mathematics as it is in medicine.

Challenges Chinese students face with mathematical learning

On the one hand, according to the international assessments such as TIMSS and PISA, in contrast to Chinese students' superior mathematics achievements in TIMSS 2019 and PISA 2012 & 2015, they in general held negative attitudes and self-confidence towards mathematics (Cao et al., 2017; Mullis et al., 2020). On the other hand, relatively speaking, Chinese students did not perform as well in the interactive problem situations, which involve problems that require students to uncover useful information by exploring problem situation (OCED, 2014). For instance, despite China and other East Asian countries topped the rest of the world in PISA 2012, their performance in the problem-solving section was at least 12 points behind those of other East Asian countries.

Unique Chinese education

Chinese education system is unique in terms of its curriculum standards and examination system. Schools from mainland China are required to follow nationwide unified curriculum standards for all teaching activities (Li et al., 2019). Examinations play a pivotal role in Chinese students' success, and students take numerous tests and examinations as soon as their education starts in Grade 1. Notably, the preparation for Zhongkao (high school entrance examination at the end of Grade 9) and Gaokao (university entrance examination at the end of Grade 12) is intense, and these tests' high-stakes status occupies all Chinese secondary school students. Only half the students are able to enter high school, and only high-scoring students are admitted to top universities, enjoying opportunities that are off-limits to lower achievers on Gaokao (Kirkpatrick & Zhang, 2011).

Aim and research questions

The research reported in this article aimed to address two research questions:

1. Which pedagogies do Chinese mathematics teachers adopt, according to their self-reports, and how do they perceive PBL and its implementation?

2. How do Chinese mathematics teachers see PBL comparing to or aligning with CT or their current teaching practices, and what new opportunities, if any, would they expect to emerge from implementing PBL?

The broader study from which the paper is derived addressed also a third research question focusing on the difficulties the teachers expected to emerge from implementing PBL.

Method

I selected schools with two main criteria: region and school ranking. In China, competition for places at top universities is less fierce in some provinces than in others due to the different availability of university places and the impact that this has on qualifying admissions scores. Thus, I selected schools from two provinces that suffer different *Gaokao* stress to gain more perspectives and to develop a more nuanced understanding of the study topic. Moreover, secondary schools are ranked by admission rates and thus compete for the best high school and college admission rates. Therefore, for the proposed research, selecting schools from different rankings could better diversify the findings.

As Table 1 illustrates, three schools/cases were selected in this study. School A is a well-known institution located in Beijing, the city that suffers less fierce competition for Gaokao; School B is one of the best secondary schools in Jiangsu Province, the province that undergoes the fiercest competition for Gaokao; School C is a mid-level school in Beijing. It is necessary to clarify that School A is an educational institution providing a large variety of learning environments and learning spaces outside of daily schooling. It holds the same goal as daily schools do (i.e., to succeed in Gaokao), follows the same curriculum standards and educational policies as do daily schools, and sets high requirements for the teachers it recruits.

Two teachers from each school participated in this study, creating three cases of two participants. All names are pseudonyms, with each participant assigned a name starting with the school's letter so that readers could easily recognise the corresponding group of each participant. For instance, participants from School A were named as A.Jack and A.Mark.

Data were collected from focus group discussions, researcher memos, and the school contexts. Three of the focus group questions are listed in Table 2 below, and these questions were then expanded as needed given the responses from the participants. At the end of each focus group, participants were given the opportunity to freely express any additional thoughts. In general, the focus group questions were separated into four major themes I used in data analysis: evaluation of CT, impressions of PBL, advantages of PBL, and disadvantages of PBL.

Table 1. School Information

Cases	School Age	Source of students	Number of teaching staff	School Location	Participants	Teaching Experience	Major
School A	20+ yrs	Ranges of all levels	700+	Beijing	A.Jack	20 yrs	Mathematics
					A.Mark	13 yrs	Mathematics
School B	200+ yrs	Top tiers	300+	Jiangsu Province	B.Nick	20 yrs	Mathematics Education

					B.Louise	18 yrs	Mathematics Education
School C	20+ yrs	Middle & low tiers	300+	Beijing	C.Lily	7 yrs	Applied Mathematics
					C.Zack	10 yrs	Applied Mathematics

Table 2. Focus group questions

Q1: Could you please describe your teaching style?	Q2. Have you heard of PBL? If so, to what degree do you understand it?	Q3. Regarding PBL, CT, and your current teaching pedagogy, what are the opportunities and disadvantages for each in the context of Chinese education? What are the relative benefits of each pedagogy in mathematics teaching?

I adopted thematic analysis – a method involves interpretation of transcripts, data classification, and theme identification – as the data analysis method. The data analysis procedure for this study followed a six-stage process advocated by Braun and Clarke (2006): (a) Become familiar with the data; (b) Generate initial codes; (c) Search for theme; (d) Review themes; (e) Define themes; (f) Produce the report.

Findings

Chinese teachers' teaching pedagogy

All groups revealed that their teaching pedagogies are mainly CT since direct learning is important, but also involve a combination of other exploratory approaches. All groups believed that solely using the CT approach in mathematics classrooms was likely to make students dependent on their teachers and thus inhibit students from developing their mathematical thinking skills.

Perception of PBL and its implementation

None of the participants had heard of the term of PBL before our discussion, neither did they know the specific procedure in PBL. But after I explained to them the definition, characteristics, and process of PBL, and provided one example to illustrate what the problem looks like in a PBL task, they all revealed that they had prior experience with similar student-centred pedagogies. For example, B.Nick said:

> We have previously tried similar pedagogy a few times. We gave students a big problem and asked them to form groups to cooperate and figure it out. Also, we involved the 'problem-chain' in it, so to figure out a big problem, students had to design several small problems that would help them to get into the big problem.

Overall, PBL pedagogy was relatively accepted and approved by all participants, who believed that it could improve students' problem-solving skills and attitudes towards mathematics, and viewed PBL as the ideal goal of Chinese mathematics education. However, while all participants approved of the features of PBL, they did not find it necessary to always connect mathematics problems with reality because some mathematics problems appearing in the *Gaokao* are very theoretical and abstract.

The findings are also related to equity issues. All groups considered PBL a better fit for high achievers, who possess more autonomy, high independence, and time-management capability, and thus can explore material more deeply through PBL.

However, if PBL better fits the top-tier students, it might enlarge the gap between the high- and the low-achieving students.

Moreover, School C shared two curriculum standards with me – the nationwide mathematics curriculum standards for compulsory education (2011 edition) and the unified mathematics curriculum standard for upper secondary education (2017 edition) – showing that the rationale for student-centred pedagogies such as PBL has been supported by the Chinese Ministry of Education for a decade. Such curriculum standards advocate adopting a student-centred method, cultivating students' interest and higher thinking skills, and encourage connecting mathematics with reality. They are followed as guidelines for all teaching and learning activities in Chinese basic education, and that might explain why all participants declared PBL as the ultimate goal of Chinese mathematics education.

Furthermore, according to School A, there is already one Chinese secondary school called Jinshi successfully implementing similar pedagogy in their mathematics classrooms for several years. A.Mark said that such implementation made Jinshi from a lower ranking school to one of the top three in the city within 3 years.

PBL vs. CT

The strongest theme among all six participants regarding the advantages of CT over PBL was efficiency, largely in basic concepts and theorems because students can quickly memorise the facts and apply them directly in solving simple problems. Especially since participants all felt that the preparation time for Zhongkao and Gaokao is limited, but PBL is very time-consuming compared to CT.

However, all groups believed that solely using CT in mathematics classrooms was likely to make students dependent on their teachers and thus inhibit students from developing their mathematical thinking skills. Both School A and B stated that only the students using student-centred pedagogy such as PBL could push their limits, reach a very high level of thinking and achieve the highest score. Therefore, all participants advocated combining PBL with CT and agreed that adopting the PBL approach a couple times per week would be preferable to setting it as the main pedagogy, especially since they felt that there are obstacles to overcome for PBL implementation in the classrooms.

Discussion

Participants' impression of PBL is consistent with the literature reporting that PBL develops students' problem-solving skills, interest, and confidence in learning mathematics, and renders students' critical thinking to be systematically optimised through the cooperative learning process (e.g., Kazemi & Ghoraishi, 2012).

All participants acknowledged the importance of real-world problems but found it unnecessary to always adopt authentic real-world problems in mathematics. This may explain why the real-world feature was not considered as a necessary feature in mathematics learning by many researchers (e.g., Ridlon, 2009; Savery, 2015). Thus, it seems a student-centred pedagogy that is not necessarily limited to the real-world problems might be a better fit in Chinese mathematics classrooms.

All three groups recommended combining PBL and CT rather than exclusively using any of them; this aligns with what Cao et al. (2017, p.28) mentioned: "Innovation does not mean the inevitable separation from tradition, but can be considered as a prerequisite to surpass and violate traditions." We are expected to achieve a combination and balance between PBL and CT so as to avoid the extremes.

Furthermore, participants from the same school had either strong agreement or similar opinions, while participants' opinions varied from school to school. This congruence may have been due to the participants' shared school cultures, provincial conditions, university majors, and training received in their workplaces. For instance, both participants from School B went to Jiangsu Normal University and majored in mathematics education; both participants from School C went to Beijing Normal University and majored in applied mathematics. Such congruence might also be due to the reason that one teacher's response could affect another's in the same group.

Although all participants consider PBL is better suited for high-performers, studies in other countries (e.g., Ridlon, 2009) showed that low achievers perform well and seem to gain the most in PBL environment. Therefore, future research could seek to investigate the effects of these student-centred pedagogy on Chinese low-performing students. Also, more research needs to be conducted regarding Jinshi, which may provide a great example for the successful implementation of the student-centred pedagogy in Chinese classrooms, to examine the following questions: Is such exploratory pedagogy indeed PBL? Are Jinshi's students' attitudes towards mathematics higher than the average of Chinese students? What support did the school provide to low achievers to make them high achievers?

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