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Chinese and Dutch mathematics teachers' beliefs about inquiry-based learning

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Teachers' beliefs are expected to have impact on the implementation of inquiry-based learning (IBL) in mathematics education. Moreover, Chinese and Dutch teaching cultures in mathematics seem to be very different. This paper presents results from semi-structured interviews with 30 Chinese and 19 Dutch mathematics teachers' beliefs about IBL. Statements were connected to main codes and ranked for each country. Dutch teachers focused on students' taking responsibility in IBL while Chinese teachers put extra emphasis on teacher guidance, they also talked about student discussion and collaboration. Chinese teachers paid attention to the benefits of IBL on mathematical thinking while Dutch teachers to the benefits on mastery and appliance of knowledge. In addition to the lack of time and suitable tasks as difficulties, Chinese teachers also mentioned students' lack of motivation and performance, while Dutch teachers mentioned the demands and openness of IBL.

Keywords: Mathematics education, inquiry-based learning, comparative study, teacher belief, lower-secondary education.

Introduction

As an intentional student-centered pedagogy rooted in the Western teaching culture, inquiry-based learning (IBL) encourages students to take responsibilities in the learning process, to explore by themselves, and to construct knowledge through actively participating in cycles like questioning, hypothesizing, designing, investigating, analyzing and reflecting (Swan, Pead, Doorman, & Mooldijk, 2013).

The understanding and implementing of IBL may be impacted by teaching cultures, while teaching culture of the East Asia is considered remarkably different from that of the West. These two teaching cultures have been identified and compared, which seemed to produce some stereotypes (Leung, 2001). From these stereotypes, the East Asia emphasizes learning content and related skills (Correa, Perry, Sims, Miller, & Fang, 2008; Leung, 2001) and values in-depth knowledge (Norton & Zhang, 2018), while the West emphasizes learning process (Leung, 2001) and values practical knowledge (Norton & Zhang, 2018); the East Asia conducts instruction to the whole class of students, while the West adopts individualized learning and group work (Leung, 2001); the East Asia considers teachers as the center and conducts well-organized directive instruction to deliver knowledge to students (Leung, 2001), while the West considers students as the center and encourages them to construct knowledge actively (Liu & Feng, 2015); the East Asia makes students learn by memorizing and practicing repetitively (Liu & Feng, 2015; Tan, 2015), while the West encourages meaningful learning (Leung, 2001); the East Asia motivates students by external factors such as examinations, while the West motivates students by internal factors such as interests (Leung, 2001).

These stereotypes about teaching cultures in the East Asia and the West also apply to the subject of mathematics. While the conceptualization of IBL in mathematics is less obvious (Artigue & Blomhøj, 2013). A large part of existing research focused on IBL in science, including research on science teachers' beliefs and practices of IBL (Wallace & Kang, 2004), a few of these research also included mathematics teachers (Marshall, Horton, Igo, & Switzer, 2009; Song & Looi, 2012). More attention needs to be paid to IBL specifically in mathematics.

As for the concept of IBL itself, no consensus has been reached about the definition, there exist a variety of interpretations about the IBL way of teaching approach (Furtak, Seidel, Iverson, & Briggs, 2012), especially about the amount of support provided to students, which makes IBL complicated to understand and implement for practitioners. Teachers may not have a complete understanding of IBL (Chin & Lin, 2013), and their beliefs about the detailed content of IBL tend to be diverse (Chan, 2010). In addition, IBL seems not yet a common practice embedded in daily teaching (Dobber, Zwart, Tanis, & Van Oers, 2017). Teachers' beliefs may shape their decisions and practice of implementing IBL (Saad & BouJaoude, 2012; Song & Looi, 2012; Wallace & Kang, 2004). While some studies also found a disconnect (Engeln, Euler, & Maass, 2013; Ramnarain & Hlatwayo, 2018) or a more complicated impact (Chan, 2010) between the beliefs and practice in regard to IBL. A deep understanding of teachers' beliefs towards the "complicated" IBL makes sense and may provide potential for better understanding their practice.

In an investigation into the beliefs and practices of IBL in mathematics, we explored from a students' perspective, and took China and the Netherlands as representing countries of the two teaching cultures (the east Asia and the West). The results showed that Chinese students reported more experience and preference of IBL than Dutch students, which challenge the stereotypes about the two teaching cultures. In this study, a teachers' perspective is to be explored.

The aim of this study is to present and compare Chinese and Dutch mathematics teachers' beliefs about IBL. The research questions are: What kinds of beliefs do lower-secondary mathematics teachers in China and the Netherlands have about inquiry-based learning (IBL)? What are the main similarities and differences on this issue between the two countries?

Methods

Participants

We interviewed 30 teachers from 15 Chinese schools and 19 teachers from 13 Dutch schools, all of them were teaching lower-secondary mathematics. 28 of the Chinese teachers and 9 of the Dutch teachers are female. The average age was 38 for Chinese teachers and 42 for Dutch teachers. As for the average years of teaching, it was 15 for Chinese teachers and 11 for Dutch teachers.

In China, generally a permission from school leaders makes it convenient to enter a school and conduct interviews, while teachers in the Netherlands have more freedom to accept an interview. Therefore in China we mainly contacted school leaders first, also a few local administrations, and some mathematics teachers directly, while in the Netherlands we invited individual teachers and included all teachers with interests. In both countries, participants were contacted mainly through an interpersonal network. Because of the large areas in China, we only collected data at Beijing, where

differences exist between urban and suburban schools, thus we ensured a balanced selection of eight urban schools and seven suburban schools to better represent the situation. In the Netherlands, schools at different areas are quite similar, we included different types of secondary schools¹.

Instruments

Data was collected through semi-structured interviews, which provided opportunities for teachers to express views and suit the research questions well. Without much presume about the definition or model of IBL, we left it open for teachers about their understanding of IBL.

We constructed an interview outline including general questions such as “what is your understanding of IBL” and two IBL example tasks as context to promote discussion. The tasks were chosen from materials of Primas project² and had potential for IBL, while they were not defined as IBL tasks in the interview, participants were asked questions such as “can it be used in an IBL lesson/do both versions represent IBL”.

The interview outline and example tasks were originally in English and translated into Chinese. The outline and tasks were piloted with two Dutch teachers and two Chinese teachers to make sure the questions and guidelines were clear enough and led to information we expected to collect. The pilot interviews also helped to prepare for practical issues that may happen during interviews.

Data collection and analysis

Dutch participants were interviewed from April to June of 2017, and Chinese participants from October to November in the same year. Each participant was interviewed individually for around 40 minutes, the language was English for Dutch teachers and Chinese for Chinese teachers. The participant was asked if recording can be accepted. If not, the interview would not go on. Generally, questions from the interview outline were asked in sequence, and extensive questions related to the topic were also allowed. Similar introduction and guideline were given to each participant.

All the interview recordings were turned into transcripts. The original codes were constructed mainly based on the questions from the interview outline, “teachers’ responsibility” and “students’ responsibility” were derived from literature. All transcripts were imported into Nvivo 11 and divided into sets of fragments. Each fragment represents a single idea. In the process of coding - including individual coding and discussing differences – sub codes with example quotations were developed to create a better understanding of the main codes. The coding scheme (shown in Table 1) was adjusted for several rounds to be better connected to the transcripts³.

¹ In the Netherlands, students choose after primary school (grade 6) for one of three types of secondary education: pre-vocational secondary education (VMBO), senior general secondary education (HAVO) or pre university education (VWO) (source: <https://www.government.nl/topics/secondary-education>).

² The Primas project: Promoting inquiry-based learning (IBL) in mathematics and science education across Europe.

³ For Chinese data, we analyzed and coded the original transcripts, then we translated statements and important quotations from Chinese into English.

Table 1: Coding scheme of the study

Main code	Sub code	Example
<ul style="list-style-type: none"> • General views-Basic understanding of IBL • Attitudes-Overall tendency towards IBL, Whether in favor of IBL • Prerequisite-Factors considered before implementing IBL in lessons 	Task	<ul style="list-style-type: none"> • “It is...about doing something different than just making the exercises from the book” • “I think it is very useful for the basis, but I think you cannot use it as the only way of teaching.”
	Students	<ul style="list-style-type: none"> • “I think this one (Unstructured Version B) will (represent IBL), this one (Structured Version A) not, this is too structured.” • “I think it is a very good group, I would maybe change this a bit, then I would give (Unstructured) Version B. In a lower grade like HAVO, then I would do this (Structured Version A), because otherwise they will not come any further.”
	Teacher	<ul style="list-style-type: none"> • “You need to have a repertoire of dealing with different things, you have to build that repertoire also”
	Context	<ul style="list-style-type: none"> • “They have to be ready to think about something new, even if it's very small detail, you must make them ready to do it, and sometimes you do not succeed because the circumstances are not ideal.”
<ul style="list-style-type: none"> • Activity-Things going on when implementing IBL in lessons; They are expected or planned to happen in the teacher’s lessons • Outcome-Results of implementing IBL 	Students' responsibility	<ul style="list-style-type: none"> • “They need some time for themselves to try and succeed or try and fail”
	Teachers' responsibility	<ul style="list-style-type: none"> • “I think here you should be more encouraging, and maybe come and ask how things are going, and if they need help, then ask questions.”
	Cognitive & Positive	<ul style="list-style-type: none"> • “They learned to think, and to think deeper, and to persuade the other person”
	Cognitive & Negative	<ul style="list-style-type: none"> • “And the risks, risk of if every student learns enough, it's not guaranteed”
<ul style="list-style-type: none"> • Reasons For-Factors for teachers to implement IBL • Difficulties-difficulties in implementing IBL 	Motivational & Positive	<ul style="list-style-type: none"> • “I think they would like mathematics more”
	Motivational & Negative	<ul style="list-style-type: none"> • “I think some of the kids will get discouraged, less encouraged, demotivated from like this.”
	Lead to positive results	<ul style="list-style-type: none"> • “I think it can really motivate students, it can really help them learning fast”
	Related to conditions	<ul style="list-style-type: none"> • “I just don’t find the time to do it”
<ul style="list-style-type: none"> • Strategies-Tips for implementing IBL 	Related to students	<ul style="list-style-type: none"> • “That the kids get stuck”
	Related to teachers	<ul style="list-style-type: none"> • “They can go really deep, and then they come into an area that you really don’t know the answer any more. That’s scary.”
		<ul style="list-style-type: none"> • “Not to take too big steps, make sure that is the right question for the right age, make sure it's a statement that they really discover something, like this.”

When about half of the interviews had been coded, we introduced an external researcher to the interview outline and the coding scheme, and asked her to randomly choose one Chinese interview and one Dutch interview to code. The Chinese interview was coded together, and next the Dutch interview was coded by herself, resulting in a 69% agreement.

After coding, we arranged fragments with similar views together and extracted representative statements from those groups of fragments. For each statement, we counted how many teachers expressed this view during interviews. Based on the number, we ranked all the statements within each main code and kept the four highest-ranking statements to provide an overview of beliefs that the two groups of teachers have about IBL. If there existed multiple statements at the same ranking, all of

them were kept or quitted. We counted and ranked for Chinese teachers and Dutch teachers respectively, then we compared the results between two countries.

Results

As preliminary results of this study, Table 2 shows 30 Chinese teachers and 19 Dutch teachers' beliefs on three important aspects through the four highest ranking statements within each main code. For example, 12 of the 30 Chinese teachers talked about “students explore and find a way to the problem”.

Table 2: High-ranking statements of Chinese and Dutch teachers on three aspects

Main code	CN statements	n	NL statements	n
General Views	• Students explore and find a way to the problem	12	• Students explore and find a way to the problem by themselves	15
	• Students discuss and collaborate with peers	12	• Teachers do not provide explanations before students' exploration	5
	• Teachers guide the IBL process	8	• The problem can be solved in different ways	4
	• Students think during the process	8	• Students think during the process	4
	• Students come to the conclusion	8	• Students do activities to solve the problem	4
Reasons For	• IBL develops mathematical thinking	17	• IBL leads to a better understanding, mastery and appliance of knowledge	8
	• IBL leads to a better understanding, mastery and appliance of knowledge	14	• IBL gives rise to more interests and motivates students	7
	• IBL gives rise to more interests and motivates students	11	• IBL is a way to develop general skills also necessary outside school and in future academic life and professional life	6
	• IBL is a way to develop general skills also necessary outside school and in future academic life and professional life	4	• IBL develops mathematical thinking	4
			• To prepare for examinations	4
Difficulties	• Some students do not think or participate actively	11	• Lack of time to prepare and do IBL sufficiently	12
	• Lack of time to prepare and do IBL sufficiently	10	• IBL asks for a lot from teachers to design and implement it well	10
	• Students may not perform well in IBL tasks	9	• Lack of suitable IBL tasks at hand	8
	• Lack of suitable IBL tasks at hand	7	• Teachers don't want the unpredictable results and insecurity that IBL brings	6

Note: “CN” is the abbreviation of China, and “NL” of the Netherlands. “n” means the number of teachers who expressed this view during interviews. Content in bold were the shared statements for Chinese and Dutch teachers.

Chinese teachers' beliefs about IBL

As is shown in Table 2, Chinese teachers talked about students' exploring, solving, thinking and getting the conclusion in IBL, they also connected IBL with student discussion and collaboration. In addition, emphasis was put on teacher guidance during the process. As for the reasons to implement IBL, Chinese teachers mainly focused on the benefits of IBL on mathematical thinking, knowledge and motivation, while only a few teachers paid attention to general skills developed from IBL. As for difficulties that teachers encountered in IBL, Chinese teachers pointed out factors related to students including the lack of motivation and performance in IBL, they also talked about factors related to conditions including lack of time and lack of suitable tasks.

Dutch teachers' beliefs about IBL

As is shown in Table 2, Dutch teachers emphasized students' taking responsibility in IBL. They paid attention to students' exploring, solving, thinking and doing activities (such as drawing and calculating) in IBL, and they made it explicit that students explore by themselves without getting explanations from teachers about the theory or problem-solving procedures. They also noticed that the problem used in IBL usually provided enough space for students to explore from different approaches. When it comes to the reasons for IBL, Dutch teachers talked about the benefits of IBL on knowledge, motivation, general skills and mathematical thinking, they considered IBL as preparation for examinations as well. As for the difficulties in IBL, Dutch teachers pointed out factors related to conditions including lack of time and lack of suitable tasks, they also included factors related to teachers, namely they were required a lot from IBL, and they expressed dislike about the uncertain and uncontrollable feature of IBL.

Comparisons between Chinese and Dutch teachers' beliefs about IBL

As is shown by statements in bold in Table 2, Chinese and Dutch teachers shared some beliefs about IBL. Teachers in both countries paid attention to students' responsibility in IBL and mentioned students' exploring, solving and thinking. They both took the four benefits of IBL (on knowledge, mathematical thinking, motivations and general skills) as reasons to implement it. Moreover, they listed two common difficulties related to conditions, namely lack of time and lack of suitable tasks.

The differences between Chinese and Dutch teachers' beliefs about IBL are apparent in Table 2. As for the general views of IBL, Dutch teachers mainly emphasized students' responsibility in IBL while Chinese teachers also paid attention to teacher guidance (such as promoting students by questions) during the process. Chinese teachers talked about student discussion and collaboration and the attainment of results in IBL as well. The shared four benefits of IBL rank differently as reasons for IBL that Chinese teachers emphasized mathematics thinking most while Dutch teachers focused on knowledge most. Dutch teachers talked more about general skills, they also mentioned IBL as preparation for examinations. As for the difficulties in IBL, Chinese teachers listed factors related to students about their lack of motivation and performance in IBL, while Dutch teachers mentioned factors related to teachers that they considered IBL as demanding, uncertain and difficult to control.

Discussion

Our findings are based on the samples from convenient sampling. Chinese data was only collected at Beijing with more advantaged educational resources, most Dutch teachers had connections with universities or research institutes, participants may be more active in exploring new teaching approaches. In addition, this study was limited to reported beliefs and lacked observations of actual lessons. Finally, although we tried to ensure a shared understanding of IBL by providing example tasks during interviews, the data might be biased if participants having different interpretations of a term like "inquiry" that originated from science education (Beumann & Geisler, 2019)

Despite the limitations of the study, some findings are in line with stereotypes about teaching cultures in the East Asia and the West. The attention of Chinese teachers on attainment of results, student performance, mastery and appliance of knowledge as well as teacher guidance in IBL match the

stereotypes that the East Asia emphasizes learning content (Correa et al., 2008; Leung, 2001) and teachers' role in instruction. The attention of Dutch teachers on students' doing activities, general skills, students' taking responsibility before teacher explanation and student motivation match the stereotypes that the West emphasizes learning process (Leung, 2001) and practical knowledge (Norton & Zhang, 2018), encourages students' constructing knowledge (Liu & Feng, 2015) and meaningful learning, and values students' internal motivations (Leung, 2001).

However, some findings are not in line with the stereotypes. The attention of Chinese teachers on students' exploring, solving and thinking, on student discussion and collaboration as well as on student motivation do not match the stereotypes that the East Asia conducts teacher-centered directive instruction to deliver knowledge (Leung, 2001), makes students learn by memorizing and practicing repetitively (Liu & Feng, 2015; Tan, 2015), conducts instruction to the whole class with little group work (Leung, 2001) and ignores students' internal motivations. The attention of Dutch teachers on knowledge and preparing students for examinations do not match the stereotypes that the West focuses on learning process more than learning content, and emphasizes students' internal motivations more than external motivations such as examinations (Leung, 2001).

Follow-up study will analyze other topics from the interviews such as IBL activities and IBL outcomes, we will also include the reported IBL practice of Chinese and Dutch teachers to see to what extent the reported practice match their beliefs about IBL, whether the beliefs shape the practice in regard to IBL or there exists a more complicated relation between them as suggested by literature.

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