



Inquiry-Based Learning Practices in Lower-Secondary Mathematics Education Reported by Students from China and the Netherlands

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Received: 1 October 2019 / Accepted: 17 August 2020 / Published online: 9 September 2020

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Abstract

Inquiry-based learning (IBL) emphasizes learning through experiencing and constructing. Where IBL is often applied in science education, the conceptualization of IBL practices in mathematics education is less obvious. We compared students' reports on IBL practices in two different teaching cultures as an attempt to better understand IBL practices in connection with overarching teaching cultures. In this study, we investigated IBL practices in lower-secondary mathematics lessons in the Beijing area and the Netherlands through a survey about the experiences and preferences of 858 Chinese students and 441 Dutch students. Results show that students from the Beijing sample reported experiencing IBL activities in most mathematics lessons, while students from the Dutch sample reported them in some lessons, and both preferred the same amount of IBL activities as they experienced. The Dutch sample reported little experience with posing questions to tackle. The study also suggests a correlation between IBL experience and IBL preference of each class: students with more IBL experience are likely to show a higher preference for IBL activities. Results of this study do not confirm expectations based on stereotypes about the two teaching cultures. The students' perspective in both samples suggests that providing complex problems and organizing group work have potential for further encouraging IBL in mathematics.

Keywords Comparative study · Inquiry-based learning · Lower-secondary education · Mathematics education · Student perspective

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Introduction

Inquiry-based learning (IBL) is a teaching approach which emphasizes learning through experiencing and constructing. IBL encourages students' autonomy in the learning process and involves student-centered learning activities such as problem-solving, investigation, and collaboration. Since "inquiry" used to be employed almost exclusively to describe science (Ibrahim, Aulls, & Shore, 2017), and IBL emerged in science education, the conceptualization of IBL practices in mathematics education is less obvious (Artigue & Blomhøj, 2013). Teaching is considered as a cultural activity (Cai, Mok, Reddy, & Stacey, 2016), and as IBL is a teaching approach, the use of IBL may be impacted by teaching cultures. Comparing IBL practices in contexts of different teaching cultures tends to reveal particular features that can be explained by each teaching culture and the shared features crossing cultural boundaries, which leads to a better understanding of the current IBL practices. Teaching cultures in East Asia and in the West are considered to be markedly different (Yang, Kaiser, König, & Blömeke, 2019). We took Beijing and the Netherlands as examples of these two teaching cultures to investigate IBL practices in mathematics reported by students. Although Beijing and the Netherlands have their own regional characteristics, they are also part of and share characteristics of their overarching teaching culture. The research questions are: What do students in Beijing and the Netherlands report about their experience and preference with respect to IBL in lower-secondary mathematics education? What are the shared and particular features on this issue between the two areas? To what extent can the particular features be explained by characteristics of the two teaching cultures?

Background: IBL in East Asian and Western Education

IBL is an intentional student-centered pedagogy that challenges learners to explore problem situations before formal explanations and solution procedures are provided (Marshall, Smart, & Alston, 2017). These explorations are intended to involve students in processes inspired by the inquiry cycle, such as questioning, hypothesizing, designing, investigating, analyzing, evaluating, and reflecting (Swan, Pead, Doorman, & Mooldijk, 2013). Instructions considered as IBL vary a lot in different interpretations (Ibrahim et al., 2017; Turner, Keiffer, & Salamo, 2018), especially on the degree that students direct and monitor the learning process (Modrek, Kuhn, Conway, & Arvidsson, 2017) and on the amount of guidance that the teacher and teaching materials provide (Bruder & Prescott, 2013). A distinction has been made between open inquiry where students can choose a topic and are fully responsible for inquiry processes, guided inquiry where the teacher is responsible for topics and guides the inquiry processes, and structured inquiry where the teacher structures and exemplifies inquiry processes that students are expected to follow (Bruder & Prescott, 2013). In this study, we interpreted IBL as a teaching culture and classroom practices in which students take responsibility in inquiry processes (Dobber, Zwart, Tanis, & Van Oers, 2017; Maaß & Doorman, 2013). For students to take this responsibility, the teacher is responsible for guiding inquiry by creating problem situations and providing support and organizing student collaboration and communication (Artigue & Blomhøj, 2013).

IBL was originally envisioned in science education (Ibrahim et al., 2017) and consequently a large part of existing research focused on IBL in science. Although advocated in policy documents, IBL does not seem to be a routine in daily teaching (Dobber et al., 2017). According to the results of PISA 2015, one in four students or even fewer reported designing own experiments or doing laboratory experiments (Organisation for Economic Co-operation and Development [OECD], 2016). The PISA 2015 index of IBL in lower-secondary science education turned out to be rather similar for China¹ (−0.25) and the Netherlands (−0.27) and both are below the OECD average (0.16) (OECD, 2016). A European study presented that mathematics teachers reported less use of IBL than science teachers² (PRIMAS, 2013). Besides large-scale international studies and studies focusing on science education, more attention also needs to be paid to in-depth studies on IBL in mathematics education. For instance, 986 US teachers reported in a study that they typically spent 34% of the time on IBL during a mathematics lesson, which is quite significant (Marshall, Horton, Igo, & Switzer, 2009). However, researchers also have pointed out the limitation of reporting IBL practices solely from a teachers' perspective, which may result in IBL practices being over-reported (Capps, Shemwell, & Young, 2016). Consequently, a study into a students' perspective on IBL is expected to enrich our understanding of current practices.

IBL is a teaching approach rooted in the Western teaching culture. The East Asian teaching culture seems to differ in many ways from that in the West, which probably has effects on the implementation of IBL. Features of each teaching culture have been identified, gradually leading to stereotypes about teaching cultures in East Asia and the West (Leung, 2001, 2005), also for the subject of mathematics (summarized in Table 1). These stereotypes mainly include dimensions of content versus process, whole-class versus individualized, teacher-centered versus student-centered, rote-like versus meaningful, and externally motivated versus internally motivated (Leung, 2001). Beijing is an East Asian city and the Netherlands is part of the Western teaching culture. Based upon the existing stereotypes, it can be expected that Dutch students would report much experience and preference related to IBL, while students in Beijing would not. It can also be expected that not many shared IBL-related features could be identified, and the differences would be in line with and be explained by the two teaching cultures.

Recent curriculum changes in both countries might also have an impact on teaching practices. The Chinese mathematics curriculum standard since 2001 required textbooks to provide space for students to investigate and communicate and encouraged teachers to organize inquiry and collaboration in lessons (Wang, Liu, Du, & Liu, 2018). The revised curriculum standard in 2011 paid attention to students' experience in mathematics activities and mathematics thinking and encouraged students to pose questions themselves (Lv & Cao, 2018). Dutch mathematics education was influenced by Realistic Mathematics Education (RME) until the beginning of this century, when criticism and debates emerged (Van den Heuvel-Panhuizen, 2010). The latest mathematics curriculum reform implemented in 2015 mentioned "thinking activities"

¹ Four provinces (Beijing, Shanghai, Jiangsu, Guangdong) in China took part in PISA 2015.

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

Table 1 Stereotypes about teaching cultures in mathematics in East Asia and the West

East Asia		The West	
Content-oriented	Teachers emphasize learning content and related procedures or skills; they value the purity, generality, and logic of mathematics and take mathematics as the product of structured in-depth knowledge separated from real life (Cai, 2006; Leung, 2001; Norton & Zhang, 2018)	Process-oriented	Teachers emphasize learning through experiencing and constructing; they value the pragmatism of mathematics to solve problems and take mathematics as the process of dealing with reality, which involves practical knowledge related to real life (Cai, 2006; Leung, 2001; Norton & Zhang, 2018)
Whole-class instruction	Under the impact of collectivist orientation (Leung, 2001), teachers consider the general needs of students that they usually interact with the whole class and seldom organize group work	Individualized learning	Under the impact of individualist orientation (Leung, 2001), teachers consider particular needs of students that they usually interact with individual students and frequently organize group work
Teacher-centered instruction	Teachers act as respectable authority, expert in mathematics, and role model; students are responsible for keeping attention and suiting the learning environment (Leung, 2001; Liu & Feng, 2015; Tan, 2015). Teachers feel responsible for preparing students for high-stake examinations. Typical classroom activities include well-organized directive instruction with lecturing, drill, and practice (Leung, 2001)	Student-centered learning	Teachers act as facilitator of learning and cater to the demands of students (Leung, 2001; Mok, 2006); students act as active learners to construct their own knowledge (Liu & Feng, 2015). Teachers are responsible for providing a suitable learning environment and preparing students for mathematically literate citizens. Typical classroom activities include problem-solving, investigation, and collaboration (Leung, 2001; Liu & Feng, 2015)
Repetitive rote-like learning	Students learn by memorizing mathematical facts and doing a considerable amount of repetitive mathematical exercises (Liu & Feng, 2015; Tan, 2015)	Meaningful learning	Students learn by thoroughly understanding mathematical facts first (Leung, 2001) through experiencing problem situations and classroom activities
Externally motivated	Students are driven by extrinsic factors such as competitive high-stake examinations, and learning is considered to be through hard work (Leung, 2001)	Internally motivated	Students are driven by intrinsic factors such as interests, and learning is considered as more effective in a pleasurable way (Leung, 2001)

including problem-solving and modeling, while textbooks and examinations were also impacted by requests for more attention for basic knowledge and skills in algebra (Schoenfeld, 2014).

Taking Beijing and the Netherlands as examples of the two teaching cultures and students’ reports on IBL-related activities as data, we investigated the current situation of IBL practices in mathematics. We also looked for shared features and particular features between the two areas to provide more insight into the current practice of IBL in mathematics and into to what extent this practice is related to the overarching teaching culture.

Method

Participants

Eight hundred sixty-seven students from 30 classes in Beijing and four hundred forty-two students from 19 classes in the Netherlands participated in this study. All of them were in grade 7, 8, or 9. With ten invalid questionnaires taken out, the distribution of samples can be seen in Table 2.

To get students filling in the questionnaires, we contacted teachers and surveyed one of the classes of each teacher. In Beijing, generally, permission from school leaders makes it convenient to enter a school; therefore, we first contacted school leaders through interpersonal networks, as well as a few local administrations, and some mathematics teachers directly. We ensured a balanced selection of urban and suburban schools in Beijing. In the Netherlands, we invited individual teachers through an electronic newsletter for mathematics teachers and through personal contacts, and included all teachers who showed an interest to participate. This created a bias in the larger than average number of classes at the level of pre-university education (VWO) in the survey. Dutch schools in different areas are quite similar, with the main differences caused by the differentiated school system; therefore, we also ensured the presence of classes at the level of pre-higher vocational secondary education (HAVO) and pre-vocational secondary education (VMBO) (see Table 2). We were aware that the study used convenient sampling and we took the samples as examples for the two teaching cultures.

Table 2 Distribution of samples in the study

	Valid N	Class size	Class type	Grade of class	Student gender	Average age
Beijing Sample	858	29 ± 7	Urban: 56.6%	Grade 7: 36%	Male: 51.6%	13.2
			Suburban: 43.4%	Grade 8: 43.2%	Female: 48.4%	
				Grade 9: 20.7%		
Dutch Sample	441	23 ± 6	VWO: 72.8%	Grade 7: 16.6%	Male: 53.8%	14.4
			HAVO: 17.2%	Grade 8: 47.4%	Female: 46.2%	
			VWO/HAVO: 6.3%	Grade 9: 36.1%		
			VMBO: 3.6%			

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

Instrument

The questionnaire consists of three parts. The first part asks students' basic information, namely the gender, year of birth and grade for mathematics in the last report.

The second part contains an IBL experience scale (see Table 3), which measures a student's experience of IBL activities in mathematics lessons with 13 items: items 1–3, 5–7, and 9–15. Eight items were derived from PISA, referring to the background questionnaires from 2012 and 2015 (OECD, 2013, 2016). PISA 2015 used a selected set of nine IBL activities to test the index of IBL in science. Four items were derived from the student questionnaire and teacher questionnaire of PRIMAS³ (PRIMAS, 2013), which was an international project based on PISA and it added to PISA items. Both PISA and PRIMAS have proved to be reliable and validated. Some items were changed from a science context to a mathematics one. All items were put in first person to fit the perspective of students. Item 14, which was self-made, was added because we considered communicating solutions with peers as an essential aspect of IBL.

These 13 items are about IBL activities that represent the two categories of IBL in mathematics: students take responsibility in inquiry processes (items 3, 5, 7, 11, 13, 15) and the teacher guides the inquiry processes. The latter one can be divided into the teacher providing suitable problem situation and support (items 1, 12) and the teacher organizing collaboration and communication (items 2, 6, 9, 10, 14). This scale uses a four-point Likert scale, according to the frequency of each activity happening in mathematics lessons, students were asked to choose one from “never or hardly ever,” “in some lessons,” “in most lessons,” and “in almost all lessons.” Two additional items (items 4, 8) related to stereotypes about teaching cultures were also self-made and were included to test whether these stereotypes exist in Beijing and Dutch mathematics lessons.

The third part is an IBL preference scale, in which five items (items 1, 3, 5, 7 and 9) were selected from the IBL experience scale to measure a student's preference for IBL activities. With the use of a three-point Likert scale, it asked if a student would prefer these activities to happen “less,” “the same,” or “more” in mathematics lessons.

When translating the original questionnaire from English into Dutch and Chinese, we tried to ensure the equivalence through peer check about possible discrepancies by researchers and postgraduates and pilot surveys. During pilot surveys in each area, we asked students if they had questions about items and we optimized the questionnaires for them. We also asked two Chinese postgraduates to translate the Chinese version back into English, then compared their versions with the original questionnaire and adjusted a few words. For example, we carefully thought over the translation of “investigation” in the context of the item in both languages (“onderzoek” in Dutch and “探究” in Chinese⁴).

³ 15 items from the “students' interaction,” “reference to application,” “hands-on experience,” and “investigation” scales of PISA 2006 student questionnaire were adapted into 10 items and used in PRIMAS project for teachers and students to report IBL activities.

⁴ The word “investigation” in Chinese is literally “调查”, which came from the West and entered into the Chinese school context. It usually refers to big projects with a complete research cycle. We considered investigations in mathematics during classroom teaching, and translated it as “探究”, referring to exploring problems or issues deeply, like “inquiry” in English.

Table 3 Items of the questionnaire and their sources

Items of the questionnaire	Original items and sources
1 The teacher presents mathematical problems for which there is no immediately obvious solution procedure	The teacher presents problems for which there is no immediately obvious method of solution (PISA 2012)
2 We are required to discuss mathematical problems	Students are required to argue about science questions (PISA 2015)
3 We have the opportunity to pose questions to tackle	I give my students the opportunity to choose which questions they tackle (PRIMAS-teacher)
4 The teacher shows how problems should be solved	Self-made
5 We are allowed to design our own procedures for solving complex problems	·The teacher asks us to decide on our own procedures for solving complex problems (PISA 2012) ·Students are allowed to design their own experiments (PISA 2015)
6 We are given opportunities to explain our own ideas	Students are given opportunities to explain their ideas (PISA 2015)
7 We spend time doing investigations to test out our own ideas	·Students spend time in the laboratory doing practical experiments (PISA 2015) ·Students are asked to do an investigation to test ideas (PISA 2015)
8 We solve problems by following example solution procedures	Self-made and inspired by items from PRIMAS project: ·When we do experiments/investigations by following the instructions of the teacher (PRIMAS-student) ·The students do experiments by following my instructions (PRIMAS-teacher)
9 The teacher lets us work in pairs or small groups to come up with joint solutions	·The teacher has us work in small groups to come up with joint solutions to a problem or task (PISA 2012) ·The students work collaboratively in pairs or small groups (PRIMAS-teacher)
10 The teacher asks us to explain how we have solved a problem	The teacher asks us to explain how we have solved a problem (PISA 2012)
11 We are encouraged to ask questions when they emerged during investigations	I have students ask questions about math/scientific phenomena addressed during experiments (PRIMAS-teacher)
12 The teacher gives us extra help when we need it	I give students extra help, when they need it (PRIMAS-teacher)
13 We draw conclusions from investigations we have conducted	Students are asked to draw conclusions from an experiment they have conducted (PISA 2015)
14 We explain our solutions of the problem to other students	Self-made
15 We have the possibility to influence on how things are done during the lesson	·We have the possibility to decide how things are done during the lesson (PRIMAS-student) ·We have an influence on what is done in the lesson (PRIMAS-student)

PRIMAS-teacher refers to the teacher questionnaire of the PRIMAS project, and PRIMAS-student refers to the student questionnaire

To test the quality of the questionnaire, we performed an analysis after the pilot surveys and surveys. For the quality analysis of the surveys, firstly we checked missing values and took out ten invalid questionnaires with more than one item (5%) missing. Then, we calculated “item discrimination”; we distinguished a high-score group (27%) and a low-score group (27%) based on the average scores on the IBL experience scale and the IBL preference scale respectively, and through an independent samples *t* test, we found significant differences between the two groups on each item and on the scale, both for the Beijing sample and the Dutch sample. We also calculated “item-total correlation”; all the correlations between each item and the scale are significant. Furthermore, we calculated the internal consistency reliability (Cronbach’s alpha) of each scale. For the Beijing sample, it is 0.89 on the IBL experience scale and 0.67 on the IBL preference scale; for the Dutch sample, it is 0.74 and 0.56, respectively. The results of the quality analysis are reasonably acceptable.

Data Collection and Analysis

Dutch data were collected from April to June of 2017, and Beijing data from October to November of the same year. We asked the mathematics teachers who were willing to participate whether one of their lower-secondary classes of students could fill in the questionnaires, which were in Dutch for Dutch students and in Chinese for Beijing students, and if we could be present when handing out the questionnaires. For all the classes that were accessible, the first author was present to give a brief introduction and answer potential questions. The language used for oral communication was English at Dutch schools and Chinese at Beijing schools. For the classes that were not accessible (5 of 19 in the Netherlands and 12 of 30 in Beijing), the mathematics teacher helped to hand out and collect questionnaires in the classroom. Filling in the questionnaires usually took about 10 min.

Based on the data from student questionnaires, we performed descriptive analysis and difference analysis using SPSS 24. Firstly, we scored all the questionnaires. The IBL experience scale was scored from one to four, and the IBL preference scale from one to three. Then, we calculated the average scores on scales as well as on each item for both samples, and ranked items within the scale based on the average scores. We also calculated the average scores of each teacher/class. We were aware that we took categorical variables from four-point and three-point Likert scale as continuous variables, and the results need to be interpreted cautiously. To make sure whether significant differences exist between groups, we did an independent samples *t* test based on “area” (Beijing and the Netherlands) and “mathematics grade” (low-achievers and high-achievers, namely, students with the lowest 5% and highest 5% mathematics grade in each class). We also performed a correlation analysis between IBL experience and IBL preference based on each teacher/class and based on each student. We further identified similarities and differences for students’ reported IBL experience and IBL preference between the two samples and compared the differences with the stereotypes about the two teaching cultures.

Results

IBL Practices in Lower-Secondary Mathematics Education Reported by Students from Beijing

The Beijing sample gets an overall average score of 3.05 ($SD=0.55$) on the 13 IBL experience items (ranging from one to four; see Table 4) that students generally reported experiencing in most mathematics lessons. They most experienced explaining their own ideas (item 6, $M=3.53$), and least being presented complex mathematical problems (item 1, $M=2.31$).

As for results on the five IBL preference items (ranging from one to three, see Table 4), the Beijing sample gets an overall average score of 2.45 ($SD=0.38$), i.e. that the students generally preferred the same amount of IBL activities as they experienced. They most preferred group work (item 9, $M=2.53$) to happen more, and least being presented complex mathematical problems (item 1, $M=2.23$).

By analyzing the five shared items of IBL experience and IBL preference (see Table 4, or Fig. 3 and Fig. 4), we found item 1 to be a special aspect for the Beijing sample, that is, although the students experienced less on being presented complex mathematical problems than on the other activities, they showed no preference for it to happen more.

Correlation may exist between students' IBL experience and IBL preference (see Fig. 1). For the Beijing sample, the correlation coefficient is 0.61 ($p=0.00$) if based on the average scores of each class, and 0.26 ($p=0.00$) if based on the average scores of each student. We also compared the reports of Beijing low-achievers and high-achievers and found no significant difference ($t(88)=1.71$, $p=0.09$) for their IBL experience, while low-achievers ($M=2.24$) reported significantly ($t(88)=3.69$, $p=0.00$) less IBL preference than high-achievers ($M=2.55$).

IBL Practices in Lower-Secondary Mathematics Education Reported by Students from the Netherlands

The Dutch sample gets an overall average score of 2.39 ($SD=0.43$) on the 13 IBL experience items (ranging from one to four; see Table 4) that students generally reported experiencing in some mathematics lessons. They most experienced getting extra teacher help (item 12, $M=3.41$), and least posing questions to tackle (item 3, $M=1.14$).

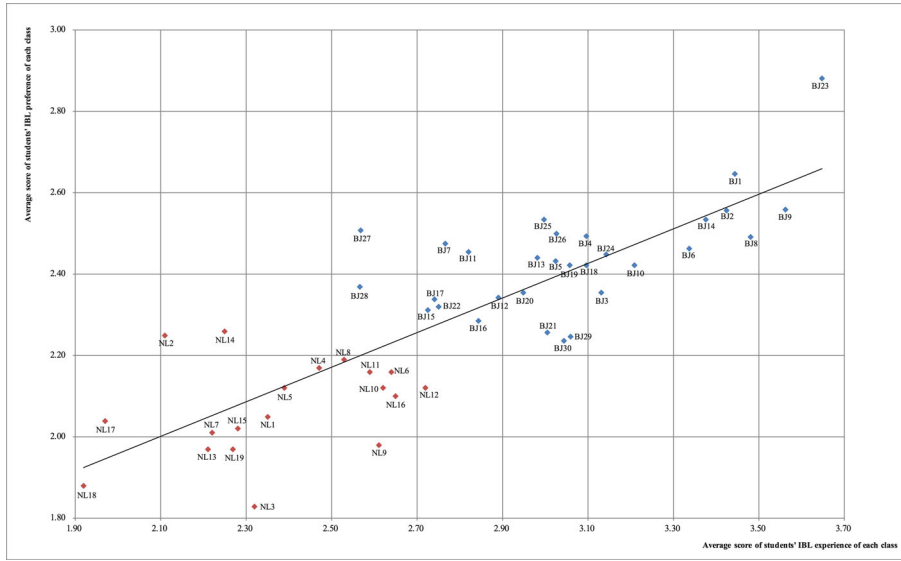
As for results on the five IBL preference items (ranging from one to three; see Table 4), the Dutch sample gets an overall average score of 2.08 ($SD=0.40$), i.e., that they generally preferred the same amount of IBL activities as they experienced. They most preferred group work (item 9, $M=2.42$) to happen more, and they preferred two activities to happen even less: being presented complex mathematical problems (item 1, $M=1.87$) and posing questions to tackle (item 3, $M=1.89$).

Item 3 is a special aspect for the Dutch sample in that, although the students experienced little ($M=1.14$) on posing questions to tackle, which never or hardly ever

Table 4 Average scores on IBL experience and IBL preference for both samples

Scale	Item	Value															Overall
		1	2	3	5	6	7	9	10	11	12	13	14	15			
BJ sample	IBL experience	M	2.31	2.68	3.33	3.30	3.53	2.91	2.62	3.36	3.46	3.41	3.01	3.10	2.65	3.05	
		SD	0.82	0.96	0.82	0.82	0.70	0.89	1.05	0.76	0.74	0.76	0.88	0.87	0.95	0.55	
	IBL preference	M	2.23	\	2.52	2.45	\	2.50	2.53	\	\	\	\	\	\	2.45	
		SD	0.63	\	0.53	0.57	\	0.57	0.59	\	\	\	\	\	\	0.38	
NL sample	IBL experience	M	2.02	2.80	1.14	2.20	2.81	2.29	2.07	2.90	2.85	3.41	2.72	2.36	1.51	2.39	
		SD	0.86	0.95	0.39	0.96	0.95	1.01	0.98	0.88	0.93	0.76	0.85	0.95	0.72	0.43	
	IBL preference	M	1.87	\	1.89	2.12	\	2.11	2.42	\	\	\	\	\	\	2.08	
		SD	0.58	\	0.73	0.62	\	0.70	0.69	\	\	\	\	\	\	0.40	

BJ is the abbreviation of Beijing and NL of the Netherlands, \ means the item was not included in the scale



Note: BJ is the abbreviation of Beijing, and NL of the Netherlands

Fig. 1 Teachers' IBL practices based on the average scores of students' IBL experience and IBL preference

happened in their mathematics lessons, they preferred it to happen even less ($M = 1.89$).

For the Dutch sample, the correlation coefficient between students' IBL experience and IBL preference (indicated in Fig. 1) is 0.35 ($p = 0.15$) if based on the average scores of each class, and 0.14 ($p = 0.00$) if based on the average scores of each student. We also compared the reports of Dutch low-achievers and high-achievers and found low-achievers ($M = 2.25$) reported significantly ($t(45) = 2.11, p = 0.04$) less IBL experience than high-achievers ($M = 2.54$), but no significant difference exists ($t(45) = 0.81, p = 0.42$) as for the IBL preference.

Comparison of IBL Practices in Lower-Secondary Mathematics Education in Both Samples

Based on the average scores of each class of students on the IBL experience scale and the IBL preference scale, the relative position of each teacher/class in both samples can be seen in Fig. 1, which presents the overview of IBL practices for all 49 teachers participating in this study. The figure clearly shows a cluster of Beijing teachers and a cluster of Dutch teachers and indicates a possible correlation between IBL experience and IBL preference of each teacher/class. We compared IBL practices reported by students in both samples and identified the shared features and particular features below.

Shared Features of IBL Practices in both Samples

Students' reports on IBL practices show similar patterns on certain IBL activities. As is shown in Fig. 2, students in both samples share the four most frequent IBL experience with items 6, 10, 11, and 12 (explain own ideas, explain solution strategies, ask questions during investigations and get extra teacher help); they also share three of the four least frequent IBL experience with items 1, 9, and 15 (being presented complex mathematical problems, group work and influencing the lesson).

In addition, students in both samples score between 2 and 3 on the IBL preference scale (see Table 4) and preferred the same amount of IBL activities as they experienced. As is shown in Fig. 4, they share the highest preference for item 9 (group work) to happen more, and lowest for item 1 (being presented complex mathematical problems).

Moreover, the correlation between IBL experience and IBL preference is strong with data of the two samples taken together (as indicated by Fig. 1), the correlation coefficient is 0.83 ($p = 0.00$) if based on the average scores of IBL experience and IBL preference of each class, and 0.39 ($p = 0.00$) if based on the average scores of these two variables of each student.

Particular Features of IBL Practices in each Sample

The Beijing sample reported experiencing IBL activities in most mathematics lessons while the Dutch sample in some lessons. Students in the Beijing sample experienced less on discussing mathematical problems than on other IBL activities, while students in the Dutch sample experienced little on posing questions to tackle and preferred it to happen even less. As for the correlation between IBL experience and IBL preference, it only exists in the Beijing sample if based on the average scores of each class, and the correlation is higher in the Beijing sample than in the Dutch sample if based on the average scores of each student. Low-achievers significantly reported less IBL preference than high-achievers in the Beijing sample, while low-achievers significantly reported less IBL experience than high-achievers in the Dutch sample.

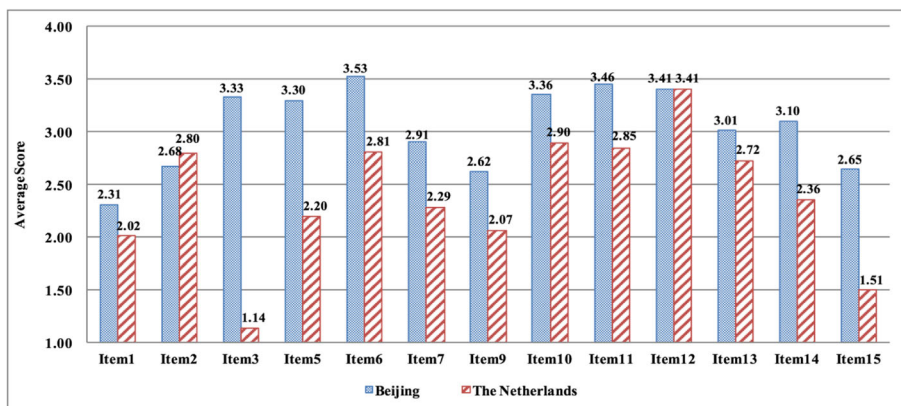


Fig. 2 Average scores of both samples on IBL experience items

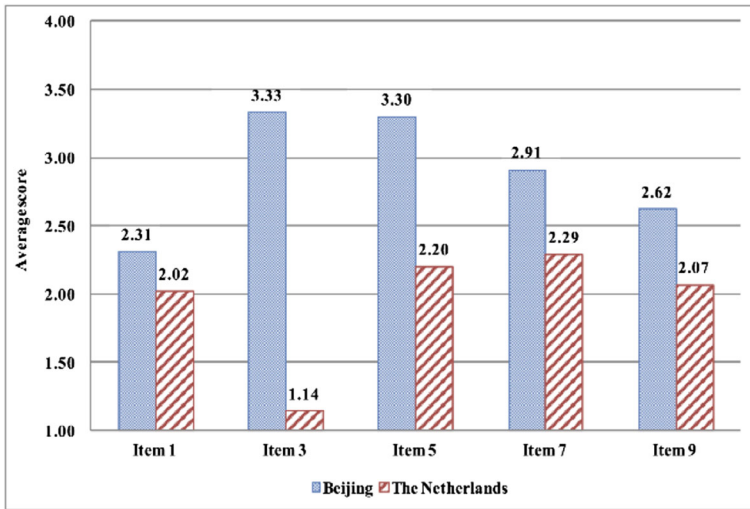


Fig. 3 Average scores on five IBL experience items

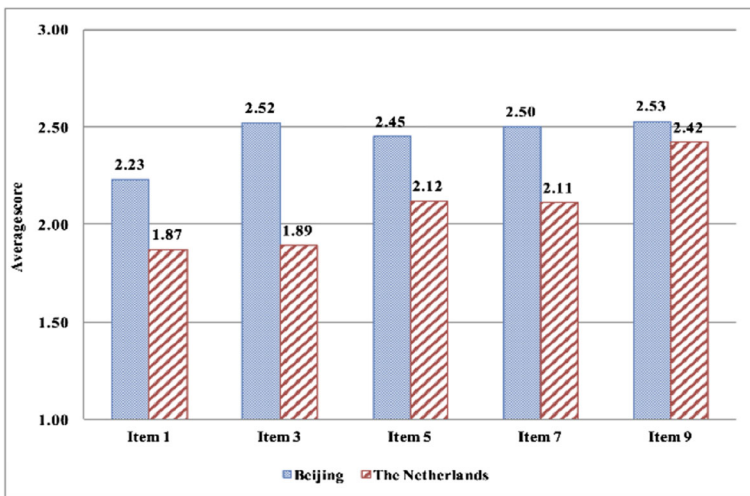


Fig. 4 Average scores on IBL preference items

Connecting Particular Features of IBL Practices in Both Samples with Stereotypes about the Overarching Teaching Culture

In the Beijing sample, students reported less experience with discussing mathematical problems than on other IBL activities, and low-achievers significantly reported less IBL preference than high-achievers. These results are in line with the whole-class instruction and externally motivated aspects of the perceived teaching culture in East Asia (Leung, 2001). This might explain our findings that low- and high-achievers do not get much opportunity to differentiate their involvement in IBL activities, while high-achievers recognize the benefits of IBL on solving complex mathematical problems in fiercely competitive examinations. In addition, students in the Beijing sample

experienced much on item 4 ($M=3.59$, the teacher shows how problem should be solved) and it supports the teacher-centered aspect. However, they reported experiencing IBL activities in most mathematics lessons, which is not in line with the teacher-centered and rote learning aspects of perceived teaching culture in East Asia.

Low-achievers in the Dutch sample significantly reported less IBL experience than high-achievers, which is in line with the individualized learning aspect of perceived Western teaching culture. However, students in the Dutch sample reported experiencing IBL activities in only some mathematics lessons, and they experienced less on posing questions to tackle than on other IBL activities. In addition, they experienced much on item 8 ($M=3.22$, solve problems by following example solution procedures). These findings do not match the student-centered and process-oriented aspects of perceived Western teaching culture.

Discussion

Our findings show that the Beijing sample reported students experienced IBL activities in most mathematics lessons, while the Dutch sample of students reported them in some lessons, and both preferred the same amount of IBL activities as they experienced. Students' report in both samples show similar patterns on certain activities, sharing the four most frequent and three of the four least frequent IBL experience. Particular features also exist for both samples, in that the Beijing sample experienced less on discussing mathematical problems while the Dutch sample experienced little on posing questions to tackle. Parts of the results are not in line with stereotypes about the teacher-centered and rote learning aspects of the perceived East Asian teaching culture, and the student-centered and process-oriented aspects of the perceived Western teaching culture. The study also suggests a positive correlation between IBL experience and IBL preference of each class.

Results of this study do not confirm expectations that could be based on stereotypes about the two teaching cultures. Students in the Dutch sample did not report much experience and preference related to IBL, while students in the Beijing sample did. The IBL practices reported by students in the two samples share quite a lot, and particular IBL-related features in each sample cannot be fully explained by stereotypes about the two teaching cultures.

Findings above are based on the samples in this study. We are aware that the study took the two samples as examples instead of representatives for the two teaching cultures, and we adopted convenient sampling, thus the results cannot be generalized to broader contexts. Most Dutch teachers in this study had relations with universities and research institutes, and a bias existed in the percentage of VWO classes that participated in the survey, which possibly led to more IBL experience reported in the Dutch sample than that in the Dutch situation, while the pattern of this result in comparison with the Beijing sample is not impacted. We also focused on reports of students without interviewing them or observing the actual practice in mathematics lessons. Moreover, we asked about the frequency of activities related to IBL in mathematics lessons, but did not evaluate the level or quality of IBL in these activities.

Nevertheless, the findings of this study challenge stereotypes about teaching cultures in East Asia and the West, especially for the dimension of so-called teacher-centered

versus student-centered approaches in mathematics education (Cai & Wang, 2010). Results support the argument from previous research that a label like “teacher-centered” does not accurately reflect East Asian classrooms, and Chinese mathematics teachers may have their own practices of student-centeredness through a framed exploratory experience (Huang, 2002; Leung, 2005; Mok, 2006), they involved students to think through questioning and variation (Gu, Huang, & Marton, 2004). The PRIMAS survey showed that the lessons of Dutch mathematics teachers could also be considered as teacher-centered (PRIMAS, 2013).

In addition, those particular IBL-related features which are not in line with stereotypes about the two teaching cultures may be explained by factors within specific context of Beijing and the Netherlands. Chinese education seemed to have borrowed some ideas, concepts, and practices from the West (Liu & Feng, 2015; Tan, 2015). The revised mathematics curriculum standard encouraged teachers to organize inquiry in lessons (Wang et al., 2018). Students in the Beijing sample may experience more classroom activities with elements of IBL than in the past, although these activities might be closer to structured or guided inquiry in the inquiry continuum. Dutch mathematics teaching is considered to have a textbook-oriented culture, i.e., teachers seem to spend much time reviewing textbook problems, and choices for learning content and lesson design are highly textbook dependent (Van den Heuvel-Panhuizen & Wijers, 2005). Limited by tasks and solutions from textbooks, students in the Dutch sample may be not used to posing questions by themselves and requests for more attention for basic knowledge and skills in algebra (Schoenfeld, 2014) might also have an impact on their IBL experience.

The findings of this study are in line with studies showing that classroom practices between the two groups of teaching cultures are not that different (Martin, Yu, & Hau, 2014) and with studies eliciting differences within a teaching culture that are ignored in such comparative studies (Clarke & Xu, 2008; Shimizu & Williams, 2013). Stereotypes about the two groups of teaching cultures need to be treated carefully.

The findings seem to match the PISA 2015 results that the two samples share a lot reported IBL practices. A surprising difference is that the Beijing sample reported IBL experience in most mathematics lessons while the Dutch sample only in some lessons.

This study also suggests a correlation between students' IBL experience and IBL preference of each class. It seems that students with more IBL experience are likely to show a higher preference, or that, when students prefer more IBL activities, teachers will adjust their teaching to include more IBL activities.

An implication for practice is that, when taking a students' perspective into account, providing complex mathematical problems, organizing group work, and encouraging students to have an influence on the lesson have potential for implementing IBL in mathematics. Mathematics teachers in Beijing need to provide more opportunities for students to discuss mathematical problems and to participate in IBL activities at their own pace, while Dutch mathematics teachers need to encourage students to pose questions to tackle. Further research can test the direction of the potential correlation between IBL experience and IBL preference of each class, and investigate why the correlation in Beijing is not present in the Netherlands.

Acknowledgments The authors thank Prof. Dongjiao Zhang, Dr. Xianglan Zhang as well as colleagues and friends that helped to contact participants, and all the teachers and students involved in this study for their contribution.

Funding This work was supported by scholarship from the China Scholarship Council (CSC) [grant number 201606040155].

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