Res Sci Educ (2020) 50:227–251
https://doi.org/10.1007/s11165-017-9687-2

Inquiry Science Learning and Teaching: a Comparison Between the Conceptions and Attitudes of Pre-service Elementary Teachers in Hong Kong and the United States

Yeung Chung Lee[1,2] · **Carole Kwan-Ping Lee**[3,4] · **Irene Chung-Man Lam**[5] · **Ping Wai Kwok**[1,2] · **Winnie Wing-Mui So**[1,2]

Published online: 20 January 2018

Abstract International studies of science education, such as the Trends in Mathematics and Science Study (TIMSS), have revealed considerable national disparities in students' achievements in science education. The results have prompted many nations to compare their science education systems and practices to those of others, to gain insights for improvement. Teacher training and professional development are key educational components that have not attracted as much attention as they deserve in international comparative studies. This study compares

✉ Yeung Chung Lee
yclee@eduhk.hk

Carole Kwan-Ping Lee
carole.lee@maine.edu

Irene Chung-Man Lam
irenecmlam@edb.gov.hk

Ping Wai Kwok
pwkwok@eduhk.hk

Winnie Wing-Mui So
wiso@eduhk.hk

1 Department of Science and Environmental Studies, Hong Kong Institute of Education, Hong Kong, SAR, People's Republic of China

2 Department of Science and Environmental Studies, The Education University of Hong Kong, 10 Lo Ping Road, Tai Po, Hong Kong

3 Department of Elementary Education, Early Childhood and Early Childhood Special Education, University of Maine at Farmington, Farmington, ME, USA

4 Education Centre, University of Maine at Farmington, 186 High Street, Farmington, ME 04938, USA

5 School-Based Curriculum Development (Primary) Section, Education Bureau, Sha Tin Government Offices, Sha Tin, Hong Kong

the conceptions and attitudes of pre-service elementary teachers (PSETs) in Hong Kong and the United States with respect to inquiry science learning and teaching *at the beginning of the semester before the start of the science methods course*. PSETs' conceptions and attitudes in the two countries were compared by means of a questionnaire with both Likert-type and open-ended questions. Quantitative data were analyzed using exploratory factor analysis and inferential statistics, while qualitative data were analyzed through the systematic categorization of PSETs' responses into broad themes and subthemes to reflect patterns in their conceptions of and attitudes toward inquiry science learning and teaching. The results revealed a complex interplay between PSETs' conceptions of and attitudes toward inquiry science learning and teaching. The results shed light on the effects of sociocultural contexts and have important implications for the design of science methods courses.

Keywords Inquiry science · Science methods course · Sociocultural context · Elementary teachers · Professional development

Introduction

Scientific inquiry is emphasized in the science curriculum frameworks of both developed and developing countries (CDC 2002a; MOE 2001; NRC 2007, 2012; QCA 2013) as a way to promote students' acquisition of inquiry process skills and an understanding of science (Llewellyn 2002; TIMSS 2011). The importance of inquiry both as part of the nature of science and a pedagogical approach provides justifications for integrating inquiry into classroom learning. For example, according to the *Next Generation Science Standards* (NGSS), science inquiry involves "the formulation of a question that can be answered through investigation" and is "one of the basics of scientific practices" (NGSS Lead States 2013), and classroom teaching needs to reflect this understanding, although the form of inquiry taking place in the classroom is dependent on the educational goals for students (NRC 2000).

However, as noted by Haigh et al. (2005), the meaning of scientific inquiry when applied to the classroom context has varied over time. It has shifted from inquiry for conceptual understanding and development of process skills to inquiry for understanding the nature of science and how science is actually practiced within the scientific community. Despite the rhetoric, the practical work conducted in the science classroom does not necessary reflect this trend, and inquiry learning for teaching science concepts or process skills through rather stereotypical approaches still prevails in many situations (Haigh et al. 2005). Ireland et al. (2014) also note that the term *inquiry* has been used rather indiscriminately to depict approaches ranging from discovery learning to transmission of knowledge. Based on phenomenographic interviews with elementary teachers, Ireland et al. (2014) identify three categories of inquiry science teaching: experience-centered, problem-centered, and question-centered, reflecting differences in teachers' perceptions about the nature of inquiry practices in science. These diverse perceptions of inquiry among practitioners suggest that further research is needed to reveal the possible factors behind these variations.

As inquiry science is interpreted differently in various research studies, we would like to define inquiry science in a broader sense in relation to classroom practices, that is, how inquiry is used as a process to engage students in thinking and reasoning in the classroom setting to *deepen their science knowledge* as argued by Plevyak (2007) and NRC (2000). With this understanding, inquiry learning refers to the process through which students learn by constructing knowledge through interpreting the results of scientific inquiry rather than through direct transmission of canonical scientific knowledge from teachers or textbooks. As such, this understanding of inquiry learning is underpinned by constructivist learning approaches, which regard conceptual learning as a process of construction based on learners' experiences gained from the inquiry process (Baker and Piburn 1997). Inquiry teaching is the pedagogy for facilitating inquiry learning and instruction (NRC 2000). In this paper, we use the terms *inquiry learning* and *inquiry teaching* interchangeably as they are the two sides of the same coin with respect to classroom contexts.

Influence of Teacher Conceptions of and Attitudes to Inquiry Science Teaching

A number of studies provide evidence that pre-service elementary teachers (PSETs)' conceptions of and attitudes toward inquiry learning influence their science teaching (Haney et al. 1996; Jones and Carter 2007; Pilitsis and Duncan 2012). PSETs who regard inquiry as an indispensable part of science and believe in a learner-centered approach to inquiry teaching and the active construction of ideas are more likely to adopt inquiry methods of instruction (Forbes and Davis 2010; Plevyak 2007; So and Watkins 2005; Varma et al. 2009). However, those who consider scientific knowledge to be *clear-cut* and *a matter of fact* tend to treat inquiry teaching as "lab-based with a step-by-step process" (Plevyak 2007).

An important finding from research about teachers' epistemological beliefs that has important implication for teachers' practice of inquiry teaching is that teachers' conceptions of the nature of science, teaching science, and learning science constitute their epistemological beliefs and are often *nested* (Tsai 2002). Tsai identifies three types of nested beliefs. The *traditional* type perceives science knowledge as truth: learning science is acquiring scientific knowledge, and teaching science is transferring knowledge to students. The *process* type perceives scientific knowledge as facts discovered by science processes, and learning and teaching science as activities focusing on these processes. The *constructivist* type views science as a way of knowing: learning science is constructing personal knowledge, and teaching science involves facilitating this construction process. Similarly, Luft and Roehrig (2007) categorize beginning secondary science teachers' epistemological beliefs into traditional, instructive, transitional, responsive, and reform-based types, reflecting different tendencies to adopt a constructivist approach to learning. This diversity of teachers' beliefs, underpinned to different degrees by positivism and constructivism, implies that *the notion of knowledge as a personal construct is perceived differently by different science teachers*. Nevertheless, Tsai's and Luft and Roehrig's models testify to the need to understand teachers' underlying epistemological beliefs about science as they are applied to classroom inquiry learning.

Apart from PSETs' conceptions of inquiry science learning, teachers' attitudes toward science learning also affect their intention to adopt inquiry teaching. Various factors have been shown to influence teachers' attitudes, such as their degree of mastery of science content (Crawford 2000; Supovitz and Turner 2000), their ability to create an inquiry-based science lesson (Luera et al. 2005), and their beliefs about students' learning abilities (Alake-Tuenter et al. 2012). Furthermore, teachers with lower self-efficacy and confidence in teaching science are less inclined to adopt a student-centered inquiry approach than those who hold more positive attitudes (Haney et al. 2002; Van Aalderen-Smeets et al. 2012). Additionally, teachers' confidence about learners' abilities influences teachers' expectations about students' learning outcomes and their own teaching practices (Dietz and Davis 2009). Hence, understanding the conceptions and attitudes of PSETs on inquiry science learning and teaching can provide important information for science educators in developing curriculum and instructional strategies. As Capps et al. (2012) and Pilitsis and Duncan (2012) have shown, conceptions of and attitudes toward inquiry instruction are key outcomes of teacher professional development.

Cross-Cultural Studies of Teachers' Conceptions of and Attitudes Toward Inquiry Science Learning and Teaching

Jones and Carter (2007) advocate cross-cultural studies to reveal the common structure underlying teachers' belief systems and explore strategies for promoting teacher professional development for inquiry learning. Their findings show that cultural context influences teachers' decision-making, attitudes, and instructional and assessment practices. In another exploratory comparative study, perceptions of the aims of practical work among science teachers in Egypt, Korea, and the United Kingdom (UK) were analyzed (Swain et al. 1999). The results showed that Korean teachers focus on fact verification and knowledge consolidation, UK teachers emphasized solving problems, and Egyptian teachers concentrated on developing students' independence and practical skills and techniques. The researchers concluded that the differences were due to teachers' attitudes to education, their perceptions of the nature of science, and the environment in which they taught.

A more recent study was conducted across 12 European countries, examining secondary teachers' current teaching practices, their beliefs about inquiry learning in mathematics and science, and factors impeding inquiry teaching (Engeln et al. 2013). Cultural differences were viewed as a major variable. All countries participated in the study reported positive attitudes toward inquiry learning. Eastern European teachers reported more frequent use of student-orientated teaching, whereas Western European teachers considered themselves to be more teacher-orientated. The authors perceive this result as striking as it did not seem to be consistent with the tradition of the two regions, with greater adherence to student-orientated teaching in Western Europe than in Eastern Europe. They postulated this rather anomalous finding as attributable to the teachers' differential conceptions of student-orientated teaching.

In light of these findings, it is clear that further cross-cultural investigation is needed to understand teachers' conceptions of and attitudes toward inquiry learning and teaching, how such conceptions and attitudes interact with each other, and how they collectively influence teachers' intended practices. If teachers possess different conceptions of inquiry teaching or learning that are mediated by culture, adopting teaching practices from one cultural context into another, e.g., a Western context to another cultural context, may be undesirable. Hence, consideration may have to be given to cultural issues rather than purely theoretical or pedagogical perspectives in designing teacher education programs. Teacher educators may need to take into account pre-service teachers' prior knowledge and experiences gained from their personal and social contexts, and create conditions that could encourage pre-service teachers to deconstruct or reconstruct their own knowledge. A cross-country comparison of teachers' conceptions of and attitudes toward inquiry learning and teaching could offer a wider perspective that allows teacher educators to reflect on the importance of cultural environment which pre-service science teacher education needs to take into account.

Research Framework

In this exploratory study, we focus on PSETs' conceptions of and attitudes toward inquiry science learning and teaching. PSETs undergo an important role transformation from learners to teachers through the science methods course. According to the constructivist paradigm, understanding PSETs' attitudes and underlying conceptions is essential in designing science methods courses that help to reconstruct PSETs' conceptions of and attitudes toward inquiry science learning. The Sociocultural Model of Embedded Belief Systems proposed by Jones and Carter (2007) indicate that teachers' beliefs consist of epistemological beliefs, which include beliefs about science, science learning, science teaching, and attitudes, which include perspectives on instruction and implementation. Both epistemological beliefs and attitudes influence teachers' motivation to engage in inquiry science teaching. Van Aalderen-Smeets et al. (2012) propose that attitudes toward teaching science are an integrated construct, comprising cognitive beliefs (perceived relevance, perceived difficulty, and gender beliefs), affective states (enjoyment and anxiety), and perceived control (self-efficacy and context dependency). All of these attitudinal attributes are subjective and interact collectively to influence teachers' instructional practices within the sociocultural context of the classroom.

Based on these models and the literature reviewed, we adopt a guiding framework which posits two domains about inquiry science learning and teaching: conceptions and attitudes. We pinpoint conceptions rather than beliefs throughout this article as the former term is more focused than the latter *as the latter encompasses the element of attitudes* (Engeln et al. 2013; Jones and Carter 2007). The conception domain consists of PSETs' views of science, scientific inquiry, and inquiry learning and teaching; the attitude domain consists of PSETs' perceived merits and challenges of inquiry learning and teaching and their self-confidence in transforming conceptions into practices. These two domains need to be examined in the wider sociocultural context of the learning of the PSETs, and such context would also influence their teaching in the classrooms in the future.

Research Questions

This cross-cultural study is guided by the following question: What are the similarities and differences in conceptions, attitudes, and intended practices with respect to inquiry science learning and teaching between PSETs in Hong Kong and the United States *before taking the science methods course*?

Context of the Study

In Hong Kong (HK), primary education is for students aged 5 to 11. Science is not an independent subject in HK primary schools but rather is integrated into other disciplines like health education and social studies. This integrated curriculum is known as General Studies (GS) (CDC 2002b). As stated in the GS curriculum guide, inquiry is emphasized as a major learning strategy comprising five scientific processes: "identifying the problem, predicting results, designing an investigation, measuring and recording, and interpreting the data" (CDC 2002b, p. 84). HK primary teachers normally base their teachings on the textbooks recommended in the Curriculum Guide developed by the HK Department of Education. Most HK primary teachers are not strong in science knowledge as they have taken science classes only up to the junior secondary level.

As students move up to the junior secondary level (ages 11 to 15), science becomes a mandatory subject. In the 1980s, HK adopted a guided discovery approach based on the UK model. Later, this model was transformed into a more student-centered inquiry approach (CDC 2002a), in which teachers relied heavily on the investigative procedures stipulated in the textbooks. The activities mainly comprise experiments for verifying or illustrating scientific principles and serve the purpose of developing scientific concepts and process skills. Beyond the age of 15, students are free to opt for science or non-science subjects. At around age 17 or 18, students need to prepare for a high-stake public examination—the Diploma of Secondary Education. Because of the heavy curriculum and tight teaching schedule, the primary emphasis of science education is examination-oriented and focused more on conceptual understanding than inquiry-based learning.

Science education in the United States (US), by contrast, starts in kindergarten and continues through the 12th grade (ages 5–18). Unlike most countries, the federal government in the US is not responsible for the education. The education policy and curricula are solely determined by each individual state. Moreover, some states give the control of education to local school districts. Hence, there is a great variation in the elements of education in the US. Inquiry learning is emphasized in the *National Science Education Standards* (NRC 1996) and, more recently, in the context of scientific and engineering practices in the *Framework for K-12 Science Education* (NRC 2012) and *Next Generation Science Standards* (NGSS Lead States 2013). Each state has a state science standard that runs from K-12 based on the national science standards. However, due to the No Child Left Behind Act in 2001 which emphasized greatly on the state standardized tests of mathematics and language arts, most elementary teachers did not spend much time on teaching science. When students come to high school level (grades 9–12), they can choose the science courses such as Physics, Chemistry, Biology, Environmental Science, Geology, Medical Science, Astronomy, and Meteorology that are offered by the school. For students with high achievement, they may take the Advanced Placement (AP) science classes and public examinations such as the Scholastic Assessment Test (SAT) or American College Testing (ACT). Some colleges will consider the SAT or ACT scores for admission while others may admit students without reviewing their test scores.

In HK, primary teachers usually follow a few recommended textbooks suggested by the Department of Education when teaching science. On the other hand, in the US, there are no standardized or recommended textbooks as stipulated by the Department of Education. US teachers have more autonomy than in HK to choose and teach science topics that they think suitable, as long as they meet the state science standards and students' needs. In both places, PSETs share the commonality of being trained as generalist rather than specialist science teachers.

Methodology

This study targeted two groups of PSETs in the US and HK to elicit their conceptions of and attitudes toward inquiry learning and teaching before their science methods courses. The US group consisted of 54 undergraduates at or above third year level in college who enrolled in a four-year program seeking a Bachelor of Science degree in Elementary Education at a university in the Northeastern United States. They belonged to two semester groups, which contained 14 and 40 students, respectively. The HK group comprised a class of 75 third-year PSETs majoring in General Studies through a four-year Bachelor of Education program at a teacher education university. For US students admitted to the science methods class, they need to have taken one laboratory science class at the college level, whereas for HK students, they would have completed some basic foundation courses intended to provide them with fundamental science knowledge. The PSETs from the two countries are considered as two different groups as the education system of the two countries is different and the two groups of PSETs are grown up in a different culture. We assume less difference within the groups as they are in the same country and have been educated in the same university for a few years.

This exploratory study involved a questionnaire (Appendix A) designed with reference to the Science Teaching Efficacy Belief Instrument (Riggs and Knochs 1990), the Composite Attitudes to Science Teaching Scale (Pell and Jarvis 2003), and other studies to a lesser extent (e.g., Altun and Kaya 1996; Choi and Ramsey 2009). The first part of the questionnaire consisted of 26 items on a Likert-type scale ranging from 5 (strongly agree) to 1 (strongly disagree). The items in the questionnaire were intended to elicit PSETs' conceptions of the nature of science and inquiry learning, confidence and attitudes in inquiry teaching, and tendency to practice inquiry teaching.

The second part of the questionnaire consists of six questions adapted from Plevyak (2007), which solicit PSETs' ideas about the implementation of an inquiry science curriculum. The questions are

1. How do you define inquiry learning in science?
2. How does inquiry learning relate to science?
3. From the students' perspectives, what are the pros and cons of inquiry learning in science?
4. From the teachers' perspectives, what are the pros and cons of inquiry learning in science?
5. What types of learning take place when you focus on inquiry learning in science?
6. Do you think you will use inquiry-based instruction when you teach? If so, how will you implement inquiry-based instruction in your future teaching? If not, what are your reasons?

The first two open-ended questions elicited PSETs' conceptions about inquiry learning in relation to science. The third and fourth questions explored PSETs' attitudes as revealed by their perceptions of pros and cons from the students' and teachers' perspectives. The fifth and sixth questions gauged their intended practices. The responses to these questions should reflect the relative importance and possible interactions of PSETs' conceptions of and attitudes toward inquiry learning and teaching in different cultural contexts. These questions were framed with a degree of openness that encouraged PSETs to explore any perspective they felt appropriate, but set reasonable boundaries to allow for a valid comparison of the two different groups. The data obtained from the open-ended questions were triangulated with those obtained from the Likert-type items. This was done by checking whether the findings derived from the two sets of data showed similar trends or patterns. For the HK group, they were allowed about 45 min to complete the questionnaire, but for the US students, there was no specific time period for them to complete. To ensure the comprehensibility of the questionnaire, a trial study was administered to a small group of 20 HK PSETs.

Results

Exploratory Factor Analysis of the 26 Likert-Type Items in the Questionnaire

Factors Influencing Inquiry Learning and Teaching

An exploratory factor analysis (EFA) was conducted to categorize the questionnaire items based on the underlying factors to facilitate comparison between the two cultural groups. The results of the first part of the questionnaire were used as the data set to conduct factor analysis. Seventy-five HK PSETs and all 54 of the US PSETs voluntarily completed the questionnaire before the start of their science methods courses. According to Gorsuch (1983) and Kline (1979), a sample size of at least 100 is required for undertaking EFA. In this study, a total of 127 cases were used, as two PSETs did not complete all the items in the pre-questionnaire.

The numerical scores for all negatively worded items were reversed before computation. A principal component analysis (PCA) was conducted on the 26 items with varimax rotation. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy index was found to be 0.80, which suggested that the sample size related to the number of items was sufficient. Bartlett's test of sphericity, $x^2 = 871.16$, $df = 136$, $p = 0.001$, was significant, which indicated that the sample was appropriate for the analysis (Hair et al. 1998; Tabachnick and Fidell 2001).

According to the results of the analysis, four factors were constructed to account for 63% of the total variance by inspection using the scree plot. Based on the criterion that factor loadings of 0.5 or greater are practically significant (Hair et al. 1998), 17 items were retained, which were categorized into four factors. Each was assigned a name to best represent the commonality of its component items.

> Factor 1—confidence/competence in teaching science concepts and facilitating inquiry science learning. This category has six items (items 13, 15, 16, 17, 25, and 26), which explain 27.4% of the total amount of variation.
> Factor 2—intention to adopt open-ended inquiry teaching approaches. This category contains four items (items 19, 20, 22, and 23), which explain 20% of the total amount of variation.
> Factor 3—perception of the nature of science. This category comprises four items (items 1, 4, 5, and 7), which explain 9% of the total amount of variation.
> Factor 4—understanding of inquiry science learning. This category has three items (items 9, 11, and 12), which account for 6.6% of the total variation.

The factor loadings vary between the values of 0.67 and 0.81 (factor 1), 0.71 to 0.83 (factor 2), 0.64 to 0.70 (factor 3), and 0.53 to 0.87 (factor 4). All item communalities range from 0.44 to 0.79 and are considered as low to moderate. Table 1 shows the loadings and communalities of all the items. Cronbach's alpha values of the four factors are 0.86, 0.84, 0.66, and 0.72, respectively (Table 2), and the overall alpha is 0.77, indicating that these factors have sufficient reliability.

Certain elements in this factor structure are rather unexpected. For instance, item 7 ("In inquiry learning, the discovery of science concepts is more important than the development of skills for inquiry") is subsumed in factor 3 rather than in factor 4. This result may indicate that this conception of inquiry learning is strongly underpinned by PSETs' perception that science is primarily concerned with knowledge discovery. In addition, item 26 ("I am confident in

Table 1 Rotated component matrix and communalities

Item no.	Factor loading				Communality
	Factor 1	Factor 2	Factor 3	Factor 4	
25	0.81				0.78
17	0.79				0.68
15	0.78				0.65
26	0.77				0.75
16	0.71				0.60
13	0.67				0.55
22		0.83			0.73
19		0.79			0.73
20		0.78			0.70
23		0.71			0.55
1			0.70		0.50
4			0.67		0.67
7			0.65		0.44
5			0.64		0.49
12				0.87	0.79
11				0.69	0.66
9				0.53	0.46

Factor 1, confidence/competence in teaching science concepts and facilitating inquiry science learning; factor 2, intention to adopt more open-ended inquiry teaching approaches; factor 3, perception of the nature of science; factor 4, understanding of inquiry science learning; all loadings smaller than 0.5 have been omitted

teaching science through inquiry-learning strategies") is subsumed in factor 1 together with five other items (13, 15, 16, 17, 25) that gauge PSETs' perceptions of their confidence or perceived competence in teaching scientific concepts. This result suggests a strong association between teaching scientific concepts and inquiry teaching, which will be discussed in a later section.

Relationships Among the Four Factors

To examine the relationships between the four factors, a Pearson correlation analysis was conducted. The results indicate that the mean score of "Intention to adopt open-ended inquiry teaching approaches" (factor 2) is positively correlated with the other three factors, namely "Confidence/competence in teaching science concepts and facilitating inquiry science learning" (factor 1) with $r(127) = 0.35$, $p = .01$; "Perception of the nature of science" (factor 3) with $r(127) = 0.32$, $p = .001$; and "Understanding of inquiry science learning" (factor 4) with $r(127) = 0.42$, $p = .001$. All of these correlations are statistically significant, and the strength of correlation varies from weak to moderate. "Perception of the nature of science" (factor 3) had a significantly strong and positive correlation with "Understanding of inquiry science

Table 2 Eigenvalue, percentage of variance, and Cronbach's alpha for each factor

Factor	Eigenvalue	% of variance	Cumulative %	Cronbach's alpha
Factor 1	4.67	27.44	27.44	0.86
Factor 2	3.40	19.97	47.41	0.84
Factor 3	1.53	8.99	56.40	0.66
Factor 4	1.12	6.60	63.00	0.72

learning” (factor 4) with $r(127) = 0.55$, $p = .001$. The results of the analysis are presented in Table 3.

From the correlation between factor 2 and the other three factors, it appears that factors 1, 3, and 4 may have an influence on PSETs’ intentions to adopt more open-ended, student-centered inquiry approaches, although this study cannot confirm any causal relationship. Among these three correlations, PSETs’ understanding of inquiry science learning is most strongly associated with their intention to adopt inquiry approaches. Combined with the very strong correlation of the PSETs’ perception of the nature of science with their understanding of inquiry science learning, it is likely that the influence of PSETs’ perceptions of the nature of science on their intention to adopt open-ended inquiry teaching approaches is mediated by their understanding of inquiry science learning. This finding seems to echo Tsai’s model of nested beliefs as discussed earlier (Tsai 2002). However, this conjecture is speculative and must be corroborated by further studies. Finally, it is worth noting that PSETs’ confidence/competence in teaching science concepts and facilitating inquiry science learning is not correlated with their understanding of inquiry learning nor with their perceptions of the nature of science. This finding implies that the teaching of conceptual knowledge and the facilitation of inquiry learning among PSETs are not necessarily underpinned by an informed understanding of inquiry learning and the nature of science.

To compare the mean scores of the four factors between the HK and US groups, an independent samples *t*-test was conducted. Compared with the HK PSETs, the US PSETs had a stronger intention to adopt open-ended inquiry teaching approaches (factor 2) and a higher score in “Perception of the nature of science” (factor 3) and “Understanding of inquiry science learning” (factor 4). All these differences were statistically significant. However, there was no statistically significant difference ($p = 0.49$) between the two groups in the scores for “Confidence/competence in teaching science concepts and facilitating inquiry-based science learning” (factor 1). The results of the *t*-tests are presented in Table 4.

As factor 1 apparently encompasses two constructs: confidence/competence in both teaching science concepts and facilitating inquiry science learning, another *t*-test was undertaken to identify differences between the two groups in each of these two aspects, which involved dividing factor 1 into two subfactors: “Confidence/competence in teaching science concepts,” consisting of all items in this factor except item 26 (“I am confident in teaching science through inquiry learning strategies”), and “Confidence/competence in facilitating inquiry science learning,” which contains only item 26, the only item measuring this aspect in this factor. The mean score of the two groups for these two subfactors was subject to an independent *t*-test. The results again showed no statistically significant difference between the two groups for both subfactors. We postulate that the PSETs’ confidence in teaching

Table 3 Means, standard deviations, and correlations

Factors	Mean	SD	Correlations			
			Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	3.17	0.66				
Factor 2	4.22	0.63	0.35**			
Factor 3	2.86	0.75	−0.01	0.32**		
Factor 4	3.42	0.81	0.06	0.42**	0.55**	

Table 4 Independent *t*-test between factors and groups

Factors	US PSETs ($n = 54$)		HK PSETs ($n = 73$)		t	p
	M	SD	M	SD		
Factor 1	3.22	0.72	3.14	0.61	0.69	0.49
Factor 2	4.59	0.40	3.94	0.62	6.75**	0.00
Factor 3	3.40	0.54	2.46	0.61	9.03**	0.00
Factor 4	4.01	0.54	2.98	0.68	9.18**	0.00

M mean, *SD* standard deviation

**$p < .01$

scientific concepts and confidence in teaching science through inquiry learning strategies are mutually reinforcing. Despite the lower degree of understanding demonstrated by HK PSETs of inquiry science learning, the findings show that HK PSETs were no less confident than their US counterparts in facilitating inquiry science learning. Hence, we further suggest that HK PSETs' confidence in facilitating inquiry science learning needs to be interpreted within their own frame of reference regarding what inquiry science learning is about.

Open-Ended Questions

The responses of the two groups of PSETs to the six open-ended questions were analyzed by categorizing them into emergent themes. Initially, broad themes were identified. The authors then progressively refined these themes into subcategories to reveal commonalities and nuanced differences in PSETs' conceptions and attitudes. All of the authors deliberated on the initial categorization of themes, after which each author was responsible for coding some parts of the data. The categorizing and coding process took place in an iterative manner. The first and second authors reviewed and finalized the categories with the consent of the other authors. For consistency, the first two authors recoded all of the data according to the final categories, and the inter-rater reliability was over 80%. Differences were resolved through negotiation and discussion.

However, there are two caveats to our analysis of the open responses. First, the PSETs might not have exhausted all their ideas in their responses to each open-ended question. However, it is reasonable to presume that the ideas they expressed were more important in guiding their behavioral intent than those left unstated. Second, due to the descriptive nature of the data, it is not appropriate to apply inferential statistical methods to our analysis. To enhance the validity of our comparison, we highlight results that show a relatively marked difference between the two cultural groups, with the corroboration of evidence collected from the Likert items. The major findings for each of the six open-ended questions are discussed in the following sections.

Definition of Inquiry Learning in Science (Question 1)

To systematically characterize the respondents' conception of inquiry science learning, a more complex method of analysis was used. The first author read through the respondents' statements and underlined key terms or phrases such as "hands-on" and "construct knowledge" that best represented PSETs' views about inquiry learning. These key words or phrases were categorized progressively to obtain broader tentative categories such as "intended outcomes of inquiry" and "learners' behaviors" to capture PSETs' perspectives on inquiry learning. The second author reviewed the first author's categorization and coding and made recommendations for changes. Both authors discussed and narrowed down the divergences until consensus was reached. The final outcomes comprised seven categories, as presented in Fig. 1.

The results showed that HK PSETs characterized inquiry learning mainly in terms of its aims, methods, and the roles of the teacher and learner. The aims were almost invariably related to understanding conceptual knowledge, and the methods were related to experimentation in a general sense. US PSETs commonly described inquiry learning in terms of the specific processes involved (e.g., "asking questions, observing, thinking about solutions on their own"; "making hypotheses, conducting hands-on research/experiments and then discussing the conclusions"), in addition to characterizing inquiry learning in terms of the inquiry method (e.g., "hands-on approach," "doing science experiments," "doing research"). Twenty-seven percent of the US PSETs as compared to 63% of the HK PSETs focused on the aims of inquiry in terms of conceptual understanding and the roles of the teachers and learners.

The differences in the characterization of inquiry learning by the two PSET groups showed that HK PSETs tended to view inquiry learning as a means to learn scientific concepts, whereas US PSETs were more process-oriented, characterizing inquiry learning as a process of doing science. However, ideas such as learners' attitudes (e.g., "creativity" and "curiosity"), the nature of reasoning involved in inquiry (e.g., "using common sense" and "discovering and reasoning"), and the context of inquiry (e.g., "going beyond the textbook") received far less emphasis in the conceptualization of inquiry learning by both groups of PSETs. Although the nature of reasoning is an important element in scientific inquiry, both groups scored low in this item (less than 15%). Most elementary teachers are generalists and thus may focus more on the doing of the activities, observation, and recording rather than the explanation and reasoning of the phenomenon. This finding echoes previous research studies which show that most teachers emphasized more on the "doing" rather than "reasoning" when doing scientific inquiry (Davis 2003; Dolan and Grady 2010;).

Relation of Inquiry Learning to Science (Question 2)

Regarding the relationship between inquiry learning and science, as shown in Fig. 2, HK PSETs were strongly inclined to consider inquiry learning as a strategy for learning science

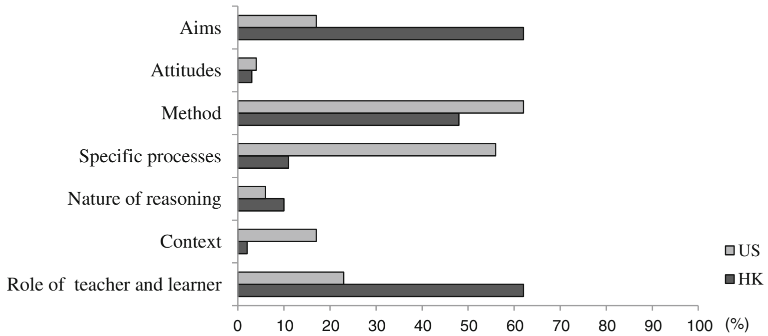

Fig. 1 Hong Kong and US PSETs' definition of inquiry learning in science

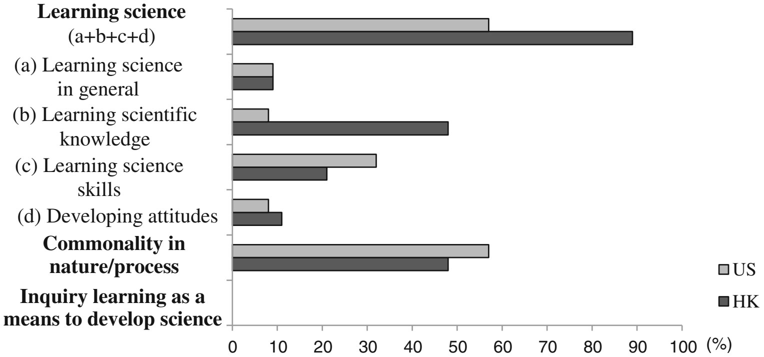

Fig. 2 Hong Kong and US PSETs' perceptions of how inquiry learning is related to science

(89%), particularly scientific knowledge (48%). This result reinforces the findings for question 1. The majority of US PSETs, however, focused on the commonality between inquiry learning and science with respect to their nature and processes. Responses provided by some of the US PSETs were

- Inquiry learning is the same process that scientists go through when they want to understand things.
- Inquiry learning relates to all subject areas in school, but in particular science because discovery is the foundation of science.
- Inquiry learning is largely based on observations, which is a main component in science and one of the most popular ways to find answers to scientific questions.

Perceived Pros from Students' and Teachers' Perspectives (Questions 3 and 4)

When PSETs were asked to suggest the pros of inquiry learning from the students' perspective, the HK group generally said that inquiry learning could foster students' positive attitudes toward science, such as an interest in science (59%) (Fig. 3). They also felt that students would

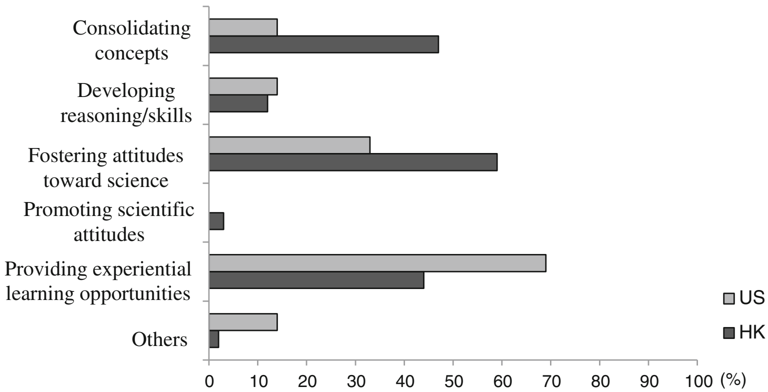

Fig. 3 Hong Kong and US PSETs' perceived pros of inquiry learning in science from the student's perspective

find inquiry learning helpful in consolidating conceptual understanding (47%). However, promoting reasoning skills was not what most HK PSETs thought students would value. Unlike their HK counterparts, US PSETs more commonly perceived that students would value the experiential learning opportunities provided by inquiry learning (69%) (e.g., "getting students more involved" and "exploring, experimenting") (Fig. 3).

US PSETs' perception of the teachers' perspective was consistent with their perception of students' views. They felt that teachers, like students, would value experiential learning. In contrast, HK PSETs envisaged greater benefits accruing to teachers' adopting inquiry learning with a 50% range, whereas US PSETs had only a 20% range (Fig. 4). The benefits were related to general pedagogical issues such as motivation and teacher-student interaction, rather than specifically related to learning science. The following are some examples of the benefits for teachers as perceived by HK PSETs.

- Inquiry teaching enlivens the learning atmosphere of the class.
- Teachers can understand students' needs better.
- Teachers can obtain feedback from students.
- Teachers can assess whether students have fully understood the topic.

One interesting finding is that HK PSETs believe that inquiry science learning would naturally help students to develop scientific attitudes, and that teachers are not the essential facilitators. US PSETs believe that the development of scientific attitudes in students is a process that occurs when the teacher is helping the students to reinforce their scientific learning.

Perceived Cons from Students and Teachers' Perspectives (Questions 3 and 4)

The majority of both US and HK PSETs shared the view that elementary students would consider inquiry learning cognitively demanding, with more US PSETs (66%) possessing this view than HK PSETs (54%) (Fig. 5). However, more US (above 30%) than HK PSETs (20%) believed that students might possess a negative attitude toward inquiry learning. Their reasons are as follows:

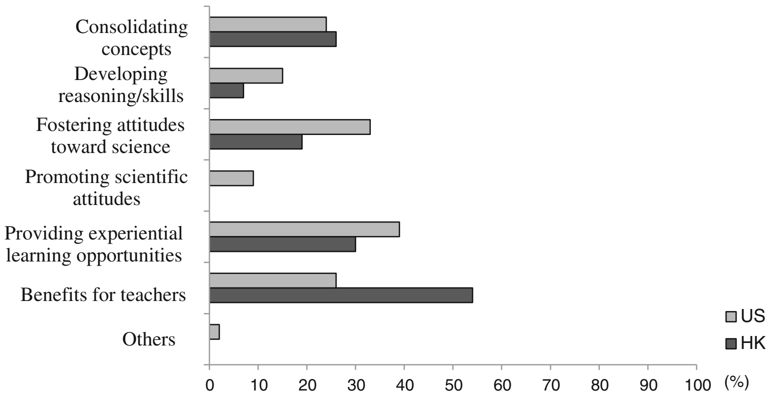

Fig. 4 Hong Kong and US PSETs' perceived pros of inquiry learning in science from the teacher's perspective

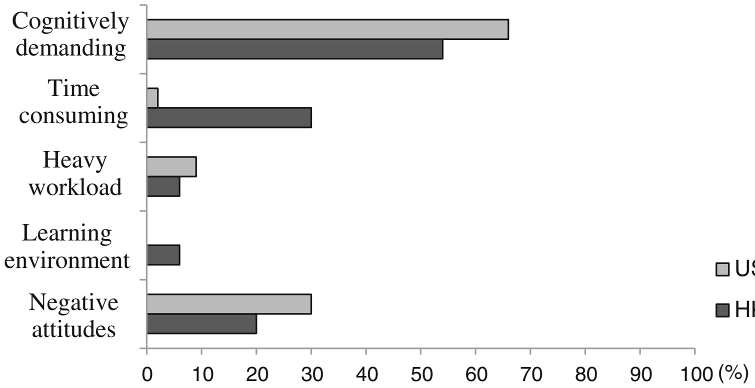

Fig. 5 Hong Kong and US PSETs' perceived cons of inquiry learning in science from the student's perspective

- Students do not like experiments.
- Students have a bad feeling if the conclusions they draw from experiments are different from the others.
- Students feel insecure, unsure about their doing.
- Students feel frustrated that they did not get the right answer.

Compared with HK PSETs, the US PSETs regarded students' lack of ability as a major problem for inquiry learning (44%) (Fig. 6). This may explain why a sizable proportion of US PSETs demonstrated a rather low self-efficacy (32%) in facilitating inquiry learning. The following responses may illustrate US PSETs' concerns about their efficacy in employing inquiry science teaching.

- I am unsure of the right and wrong decisions.
- Unable to explain/answer students' questions exactly as I am not prepared to do so.
- Must know why/how things work in order to answer students' questions.
- Who knows where it can lead.

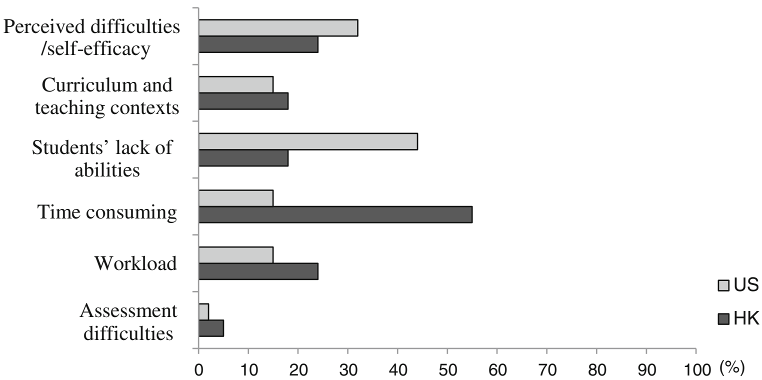

Fig. 6 Hong Kong and US PSETs' perceived cons of inquiry learning in science from the teacher's perspective

In contrast, the top negative component of inquiry learning for HK PSETs from both students' and teachers' perspective was that it is time-consuming (30 and 55%, respectively). They also perceived a heavier workload for teachers (24%). In comparison to the US group, far fewer HK PSETs regarded students' lack of ability (18%) or teachers' perceived difficulties or low self-efficacy (24%) as major drawbacks of inquiry learning.

Expected Types of Learning Taking Place in Inquiry Learning (Question 5)

Both groups expected student-directed and experiential learning (over 40%) to take place through hands-on experiences when they practiced inquiry teaching (Fig. 7) and placed only a modest emphasis on the development of science skills and reasoning (12%). Although far fewer US PSETs emphasized the utility of inquiry for facilitating concept learning, as revealed by their responses to question 1, it is remarkable that more US than HK PSETs anticipated the development of knowledge and understanding through inquiry learning, implying that knowledge and understanding were still being regarded as a major outcome of inquiry, although it should be differentiated from rote learning. It is unexpected that the US PSETs, despite their aligning more closely to a more progressive inquiry learning approach than HK PSETs, have made little reference to learning for developing scientific reasoning. This anomaly might indicate both groups of PSETs need to develop an in-depth understanding of the inquiry process and to go beyond characterizing it as a "hands-on experience." In short, the US PSETs have yet to articulate an in-depth view on inquiry science learning. Equally surprising is that far fewer US PSETs (about 5%) than HK PSETs (over 20%) perceived collaborative learning occurs in inquiry learning. It is probably because the US PSETs have been used to collaborative learning as a general learning strategy in most subjects; hence, they did not perceive it as unique to science learning.

Tendency to Implement Inquiry Instruction (Question 6)

An overwhelming majority of respondents in both localities intended to use inquiry instruction. Both groups tended to provide appropriate learning activities (Fig. 8) and facilitate students' inquiry through hands-on activities, with teachers acting as facilitators. Those PSETs

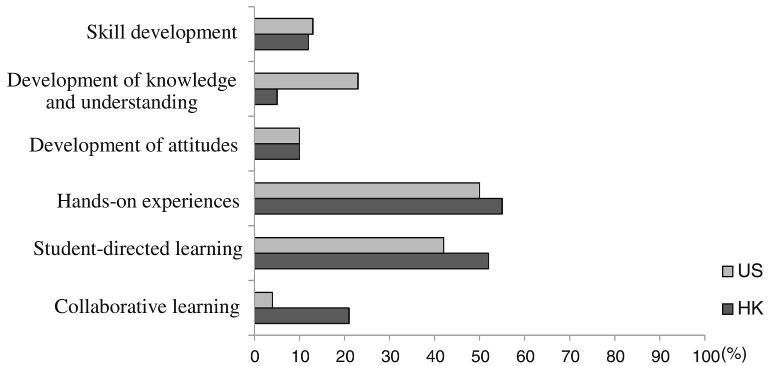

Fig. 7 Hong Kong and US PSETs' perceptions of the type of learning expected to take place in inquiry science learning

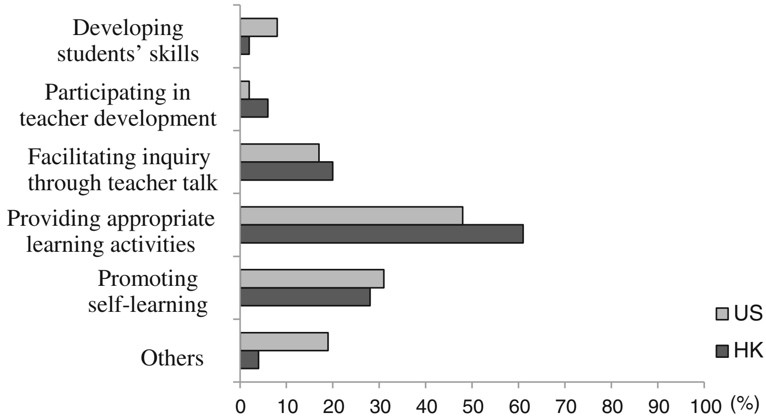

Fig. 8 A Hong Kong and US PSETs' intended use of inquiry instruction

who expressed no intention to implement inquiry teaching were mainly concerned about lack of time and heavy teaching responsibilities.

Discussion

Conceptions of PSETs About Inquiry Learning

The findings of the first part of the questionnaire show that US PSETs' understanding of the nature of science and of inquiry learning aligned more closely with that advocated by the science education literature that the main emphasis of inquiry science learning and teaching is the scientific process. The responses to the open-ended questions revealed differences in epistemological beliefs about science inquiry learning between the two PSET groups. The HK PSETs tended to adopt a more traditional view of inquiry learning and teaching, i.e., perceiving inquiry science learning as a means to develop conceptual understanding. Their frequent reference to acquiring scientific facts and concepts suggests a positivist view of science. Their comment on science inquiry learning as time-consuming further suggests an emphasis on conceptual learning by transmission rather than the development of scientific processes or reasoning, or the adoption of a constructivist approach to conceptual learning. The US PSETs generally adopted a constructivist orientation to inquiry learning, relating the inquiry process to the nature of scientific practice and focusing on students' inquiry experiences rather than aligning learning outcomes with canonical scientific knowledge. It seems that the US PSETs attached greater importance to the intrinsic value of scientific inquiry. Nevertheless, the US PSETs did recognize the benefit of inquiry learning in developing knowledge and understanding, according to their responses to the open-ended questions. Referring to the models of Tsai (2002) and Ireland et al. (2014), the HK PSETs' conceptions about inquiry learning were akin to the "traditional" type and "problem-centered" approach, whereas the US PSETs' conceptions were close to the "constructivist" type orientation and "experience-centered or question-centered" approach. Apparently, the differences in findings could be related to differences between the two cultural contexts. Because the questionnaire was administered at the beginning of the semester and both groups had not completed their respective science methods courses and formal field experience, we hypothesize that their epistemological orientation toward inquiry science learning mainly came from their previous experiences of learning science or observations of how science was taught by their teachers.

Attitudes of PSETs Toward Inquiry Learning and Teaching

The correlation analysis shows that the PSETs' confidence in teaching science concepts and facilitating inquiry learning is independent of their level of understanding of inquiry learning and the nature of science. The findings for the US and HK groups are not significantly different for confidence/competency in teaching scientific concepts and facilitating inquiry learning, even though the US group's conceptions of inquiry learning more closely reflected current inquiry science education literature. These findings imply that PSETs' evaluation of their own confidence/competency might be based on other criteria, such as their own interpretations of inquiry learning and the nature of science. This conjecture is supported by the finding that HK PSETs commonly considered inquiry learning as a means to learn scientific concepts. Another possible criterion influencing self-confidence is the PSETs' perception of the difficulty in implementing inquiry science learning as exemplified by the US PSETs. This criterion could be important to US PSETs who perceived inquiry science learning as cognitively more demanding for students and consequently more difficult for teachers. The relative negative perception of the US PSETs about inquiry learning from the students' perspective may be related to the more progressive pedagogical approach to inquiry learning of challenging students' capabilities and knowledge that they acquired in schools. More HK PSETs than their US counterparts believe that inquiry learning is beneficial to teachers and can promote students' conceptual understanding. However, HK PSETs are more concerned about contextual barriers to inquiry instruction, such as time constraints, than their US counterparts. Despite an increased emphasis on inquiry learning in the existing curriculum that accords much greater importance to the development of process skills through scientific inquiry than in the past (CDC 2002b), HK primary students scored lower than the international average on reporting and presenting their scientific inquiry in the TIMSS study of 2003 (So 2008). To a certain extent, this relatively low achievement in inquiry science may be attributed to the Chinese style of learning which emphasized memorization more than understanding, a characteristic traceable to the Confucian cultural heritage (Wong 2004). There appears to be tensions between the implementation of a more inquiry-based learning approach and the extremely high examination pressure and competitive learning environment common not only in HK but also in East Asian regions (Lau 2014). The concern about examination pressure is also voiced by Law et al. (2009) although the authors acknowledged that both teachers and students in HK have become more ready for new ways of learning and to adopt a socioconstructivist view of learning. This exploratory study of the differences in conceptions and attitudes of PSETs in two localities further suggests that such differences may be due to the disparity of their perceptions of the nature of science and the culture of learning.

Intention to Adopt Inquiry Science Teaching

Both parts of the questionnaire showed that US PSETs have greater intention to adopt inquiry teaching than the HK group. Correlation analysis shows that PSETs' intention to use inquiry teaching is positively associated with their perceptions of the nature of science, understanding of inquiry science learning, and confidence in teaching science concepts. This shows that PSETs' conceptions of and attitudes toward inquiry science learning may have a strong effect on their intention to adopt the inquiry approach in classroom teaching. These positive correlations support Jones and Carter's (2007) findings on the motivating effect of teachers' epistemological beliefs of inquiry learning on their intention to adopt such strategy in the classroom. Another benefit is that by knowing more about inquiry learning and teaching, teachers could plan and implement students' inquiry learning experiences in more effective ways (Luft et al. 2008).

Implications

Due to the limited sample size, it is difficult to generalize the findings to the wider teacher education realm, particularly for the US, where the educational context varies from state to state. Also, the survey was done before the PSETs took the science methods class, and their concepts about inquiry science teaching were likely to come from their experiences in the elementary, middle, and high schools, which may deviate from those widely disseminated in the literature. As a matter of fact, it was our intention to conduct the survey at the beginning of the semester to gauge the kind of conceptions and attitudes about inquiry learning that the PSETs would bring to the science methods classes. Based on this background, this study has shown some interesting variations between the PSETs in both places in their conceptions, attitudes, and intentions with respect to inquiry learning and teaching. HK PSETs' orientation toward conceptual learning through inquiry contrasted with the US PSETs' orientation toward experiencing inquiry as a scientific practice. This finding provides support to Engeln et al.'s (2013) hypothesis that teachers' conception of student-orientated learning may vary across geographical contexts. We do not intend to dichotomize or stereotype the beliefs of PSETs in HK and the US, although the two groups show different attributes. Further research is needed to validate the present findings and explore possible cultural factors underlying these differences. For instance, separate confirmatory factor analyses need to be undertaken in HK and the US to validate the factor structure revealed by this study.

This study's findings have four implications for pre-service teachers. First, teacher education programs in both places should accommodate PSETs' intended practices, which are the products of highly complicated interactions between epistemological, attitudinal, and sociocultural factors, and create conditions for PSETs to evaluate and reflect on their intended practices in light of other alternative positions. More specifically, before making pedagogical decisions, teacher educators should give deeper thought to how to guide PSETs based on some underlying factors that might influence their conceptions and attitudes toward inquiry science learning, e.g., PSETs' conceptions of the nature of science. On the HK side, teacher educators should lead PSETs to reflect on conceptions and aims in practicing inquiry learning that overly emphasize conceptual learning, as underpinned by the positivist paradigm, as this approach may marginalize the development of ideas about the nature of science and a genuine spirit of inquiry. This is particularly true as research has revealed many teachers were not well versed with the constructivist paradigm and still regarded science as a set of undisputable objective knowledge derived from standard methods of scientific inquiry (Bentley et al. 2000). In the study of the effectiveness of school-based professional development, Lee (2011) shared similar findings that HK primary science teachers perceived themselves as knowledge providers rather than facilitators of inquiry learning. Hence, they were strongly preoccupied with whether they are able to master the subject knowledge of science.

Second, science teacher educators should be wary of inadvertently promoting a constructivist stance toward inquiry teaching and learning to induct students into scientific practice without due consideration of the difficulties perceived by PSETs in implementing this kind of learning. Our findings show that US PSETs envisage these difficulties when attempting to practice inquiry teaching that adheres closely to the constructivist approach.

Third, as a corollary to the first two implications, science teacher educators should help PSETs develop metacognition about how their own concepts of inquiry learning developed over their early period of schooling at the beginning of the science methods course. Thomas (2003) calls metacognition “an individual’s knowledge, control, and awareness of his/her learning process” (p. 175). Science educators should help PSETs to reflect on their metacognitive learning of science, which will lead them to evaluate and regulate their conceptions of and attitudes toward inquiry teaching. The following questions are suggested as a reference for teacher’s reflection:

- What are my beliefs about the goals of science learning?
- What are my understandings of inquiry learning and teaching?
- What are my beliefs about the desirability and practicability of inquiry learning and teaching?
- How am I going to practice inquiry teaching to strike a balance among the various goals of science learning and overcome the impediments?

Fourth, apart from promoting continuous reflections among PSETs, science teacher educators in both countries should assist PSETs in reconciling the tensions between their conceptions of inquiry learning and their perceptions of its pros and cons, as such tensions inevitably influence PSETs’ intended practices. Our findings show that these tensions vary across cultural contexts. As for HK PSETs, an overemphasis on teaching scientific concepts that is dictated by the curriculum may not be conducive to the development of students’ scientific reasoning. Even for US PSETs who seemed to have a better understanding of the merits of inquiry learning, much greater emphasis was placed on hands-on experiential learning than developing students’ scientific reasoning. In connection with this, they perceived considerable difficulties in implementing inquiry learning. Hence, we may conclude there is still a wide gap to be bridged between US PSETs’ theoretical understanding of science inquiry learning and the approach they intended to take to put theory into practice.

Conclusion

Our findings provide insights into the complex interplay of four attributes regarding PSETs’ conceptions of and attitudes to inquiry science learning as revealed by the factor analysis—perception of the nature of science, understanding of inquiry science learning, confidence/competence in teaching science concepts and facilitating inquiry science learning, and intention to adopt open-ended inquiry teaching approaches. These attributes are likely to be affected by personal variables, such as past experiences with inquiry learning in schooling, and contextual variables ranging from the national or school curriculum to societal expectations of school science learning. Despite this, the two PSET groups seemed to define inquiry learning quite differently. The closer alignment of the US PSETs’ orientation toward inquiry teaching with the constructivist approach may be related to unique features of the US inquiry-oriented curricula, which has been in place for a number of years. We hypothesize that the more traditional stance adopted by HK PSETs, which views inquiry as an effective means to develop conceptual understanding, might be rooted in a positivist orientation and concept-based approach to practical work experienced by the HK PSETs when they learned science in schools. Further studies are needed to ascertain whether this orientation is common across Asian countries and whether it continues to persist in HK and elsewhere in other

Asian countries as these countries are riding on the waves of science curriculum reform of moving science learning toward a constructivist paradigm.

We would like to reiterate that the present findings were obtained before the PSETs undertook their science methods courses. So, their conceptions, attitudes, and intention to adopt inquiry science teaching are likely to change after going through the methods courses. Nevertheless, these findings could help teacher educators plan their science methods courses in such a way as to build on their students' prior conceptions. However, in light of the absence of a common belief system across cultures and the complexity of the formation of concepts of and attitudes to inquiry learning as they interact with a multitude of sociocultural factors, there is no "one size can fit all" teacher education program. Engaging PSETs with metacognition about inquiry learning and teaching is a promising step forward. However, challenging PSETs to identify and reflect on the limitations of their initial conceptions of and attitudes toward science and inquiry learning in meeting national/state science standards needs to be followed up by explicit discussions with PSETs on how to cope with tensions between the pros and cons of inquiry teaching and the impediments to implementation. The findings of this study point to the need for further studies of the nuanced interactions between local educational contexts and PSETs' conceptions and attitudes toward inquiry learning. It is important for us to create a favorable condition to help PSETs overcome their challenges of inquiry science learning and teaching so that they can provide a better experience for their students to learn science.

Appendix A

Part I:

Please indicate the degree to which you agree or disagree with each statement below by circling the number.

5 = strongly agree (SA)

4 = agree (A)

3 = Uncertain (U)

2 = disagree (D)

1 = strongly disagree (SD)

	5 SA	4 A	3 U	2 D	1 SD
1. Science is a body of objective knowledge.	○	○	○	○	○
2. Science is exploring the unknown.	○	○	○	○	○

3.	Scientific knowledge is tentative.	○	○	○	○	○
4.	There is a specific way of doing science.	○	○	○	○	○
5.	The main purpose of scientific inquiry is to seek absolute truth.	○	○	○	○	○
6.	The main goal of inquiry learning in science is to allow students to re-discover or verify the scientific concepts stated in the textbook.	○	○	○	○	○
7.	In inquiry learning, the discovery of science concepts is more important than the development of skills for inquiry.	○	○	○	○	○
8.	Inquiry learning in science is usually a result of collaborative effort between students.	○	○	○	○	○
9.	It will be a problem if students cannot obtain the intended results through inquiry activities.	○	○	○	○	○
10.	Primary students are capable of doing inquiry activities in science to seek new knowledge not found in the textbook.	○	○	○	○	○
11.	Inquiry learning in science is too challenging for primary students as there are too many uncertainties in the inquiry process.	○	○	○	○	○
12.	Inquiry learning is not an effective way for primary students to learn science as it is difficult to obtain the correct answers from the activities.	○	○	○	○	○
13.	I think I know how to teach science concepts.	○	○	○	○	○
14.	I am not confident enough in guiding students doing science activities.	○	○	○	○	○
15.	I think my science knowledge is sufficient to teach primary science.	○	○	○	○	○
16.	I find it difficult to explain to students why science experiments work.	○	○	○	○	○
17.	I think I am able to answer students' questions related to science.	○	○	○	○	○
18.	I wonder if I have the necessary skills to teach science.	○	○	○	○	○
19.	If I am to teach science, I would welcome student	○	○	○	○	○

	questions.					
20.	If I am to teach science, I would encourage open-ended discussion.	○	○	○	○	○
21.	To engage students in inquiry learning in science, I must be proficient in science content knowledge.	○	○	○	○	○
22.	I would encourage students to try out their own ideas in investigations.	○	○	○	○	○
23.	I am willing to explore inquiry teaching in science beyond the information that are provided in syllabi or textbooks.	○	○	○	○	○
24.	I can devise activities which involve student participation in inquiry learning in science.	○	○	○	○	○
25.	I am confident in teaching science concepts	○	○	○	○	○
26.	I am confident in teaching science through inquiry-learning strategies.	○	○	○	○	○

Part II:

The following are some open-ended questions, please answer them as far as you can. (You may use Chinese or English in answering these questions.)

1. How do you define inquiry learning in science?
2. How does inquiry learning relate to science?
3. From the students' perspectives, what are the pros and cons of inquiry learning in science?
4. From the teachers' perspectives, what are the pros and cons of inquiry-based instruction?
5. What type of learning takes place when you focus on inquiry learning in science?
6. Do you think you will use inquiry-based instruction when you teach? If so, how do you do it?

References

Alake-Tuenter, E., Biemans, H. J. A., Tobi, H., Wals, A. E. J., Oosterheert, I., & Mulder, M. (2012). Inquiry-based science education competencies of primary school teachers: a literature study and critical review of the American National Science Education Standards. *International Journal of Science Education, 34*(17), 2609–2640.

Altun, E. H., & Kaya, S. (1996). Measurement of the confidence, attitudes, and self-image of Turkish student-teachers in relation to chemistry education. *International Journal of Science Education, 18*(5), 569–576.

Baker, D. R., & Piburn, M. D. (1997). *Constructing science in middle and secondary school classrooms*. Boston: Allyn and Bacon.

Bentley, M. L., Ebert, C., & Ebert, E. S. (2000). *The natural investigator: a constructivist approach to teaching elementary and middle school science*. Belmont: Wadsworth/Thomson Learning.

Capps, D. K., Crawford, B. A., & Constas, M. A. (2012). A review of empirical literature on inquiry professional development: alignment with best practices and a critique of the findings. *Journal of Science Teacher Education, 23*, 291–318.

Choi, S., & Ramsey, J. (2009). Constructing elementary teachers' beliefs, attitudes, and practical knowledge through an inquiry-based elementary science course. *School Science and Mathematics, 109*(6), 313–324.

Crawford, B. (2000). Embracing the essence of inquiry: new roles for science teachers. *Journal of Research in Science Teaching, 37*, 916–937.

Curriculum Development Council (CDC). (2002a). *Science education: key learning area curriculum guide (primary 1–secondary 3)*. Hong Kong: CDC.

Curriculum Development Council (CDC). (2002b). *General studies for primary schools curriculum guide (primary 1–6)*. Hong Kong: CDC.

Davis, K. S. (2003). Change is hard: what science teachers are telling us about reform and teacher learning of innovative practices. *Science Education, 87*(10), 3–30.

Dietz, C. M., & Davis, E. A. (2009). Pre-service elementary teachers' reflection on narrative images of inquiry. *Journal of Science Teacher Education, 20*, 219–243.

Dolan, E., & Grady, J. (2010). Recognizing students' scientific reasoning: a tool for categorizing complexity of reasoning during teaching by inquiry. *Journal of Science Teacher Education, 21*(1), 31–55.

Engeln, K., Euler, M., & Maass, K. (2013). Inquiry-based learning in mathematics and science: a comparative baseline study of teachers' beliefs and practices across 12 European countries. *ZDM Mathematics Education, 45*, 823–836.

Forbes, C. T., & Davis, E. A. (2010). Curriculum design for inquiry: pre-service elementary teachers' mobilization and adaptation of science curriculum materials. *Journal of Research in Science Teaching, 47*, 820–839.

Gorsuch, R. L. (1983). *Factor analysis* (2nd ed.). Hillsdale: Erlbaum.

Haigh, M., France, B., & Forret, M. (2005). Is "doing science" in New Zealand classrooms an expression of scientific inquiry? *International Journal of Science Education, 27*, 215–226.

Hair, J., Anderson, R., Tatham, R., & Black, W. (1998). *Multivariate data analysis* (5th ed.). Upper Saddle River: Pearson/Prentice Hall, Inc..

Haney, J. J., Czerniak, C. M., & Lumpe, A. T. (1996). Teacher beliefs and intentions regarding the implementation of science education reform strands. *Journal of Research in Science Teaching, 33*(9), 971–993.

Haney, J. J., Lumpe, A. T., Czerniak, C. M., & Egan, V. (2002). From beliefs to actions: the beliefs and actions of teachers implementing change. *Journal of Science Teacher Education, 13*(3), 171–187.

Ireland, J., Watters, J. J., Brownlee, J. L., & Lupton, M. (2014). Approaches to inquiry teaching: elementary teacher's perspectives. *International Journal of Science Education, 36*(10), 1733–1750.

Jones, M. G., & Carter, G. (2007). Science teacher attitudes and beliefs. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 1067–1104). Mahwah: Lawrence Erlbaum Associates.

Kline, P. (1979). *Psychometrics and psychology*. London: Academic.

Lau, K. C. (2014). The science education of the East Asian regions—what we can learn from PISA. *Asia-Pacific Forum on Science Learning and Teaching, 15*(2), Article 9 (December, 2014). Retrieved from http://www.eduhk.hk/apfslt/.

Law, N. W. Y., Yuen, A. H. K., Chan, C. K. K., Yuen, J. K. L., Pan, N. F. C., Lai, M., & Lee, S. L. (2009). New experiences, new epistemology, and the pressures of change: the Chinese learner in transition. In C. K. K. Chan & N. Rao (Eds.), *Revisiting the Chinese learner: changing contexts, changing education* (pp. 89–129). Hong Kong: Comparative Education Research Centre, The University of Hong Kong.

Lee, Y. C. (2011). Enhancing pedagogical content knowledge in a collaborative school-based professional development program for inquiry-based science teaching. *Asia-Pacific Forum on Science Learning and Teaching, 12*(2), Article 3 (December, 2011). Retrieved from http://www.eduhk.hk/apfslt/.

Llewellyn, D. (2002). *Inquire within: implementing inquiry-based science standards*. Thousand Oaks: Corwin.

Luera, G. R., Moyer, R. H., & Everett, S. A. (2005). What type and level of science content knowledge of elementary education students affect their ability to construct an inquiry-based science lesson? *Journal of Elementary Science Education, 17*(1), 12–25.

Luft, J. A., & Roehrig, G. H. (2007). Capturing science teachers' epistemological beliefs: the development of the teacher beliefs interview. *Electronic Journal of Science Education, 11*(2), 38–63.

Luft, J. A., Bell, R. L., & Gess-Newsome, J. (2008). *Science as inquiry in the secondary setting*. Arlington: NSTA.

Ministry of Education (MOE). (2001). *Science (grades 3–6) curriculum standards, China*. Beijing: Beijing Normal University Press.

National Research Council (NRC). (1996). *National Science Education Standards*. Washington, DC: National Academy.

National Research Council (NRC). (2000). *Inquiry and the National Science Education Standards: a guide for teaching and learning*. Washington, DC: National Academy.

National Research Council (NRC). (2007). *Taking science to school: learning and teaching science in grades K-8*. Washington, DC: National Academy.

National Research Council (NRC). (2012). *A framework for K-12 science education: practices, crosscutting concepts, and core ideas*. Washington, DC: National Academy.

NGSS Lead States. (2013). *Next generation science standards: for states, by states*. Washington, DC: National Academies Retrieved from www.nextgenscience.org.

Pell, A., & Jarvis, T. (2003). Developing attitude to science education scales for use with primary teachers. *International Journal of Science Education, 25*(10), 1273–1295.

Pilitsis, V., & Duncan, R. G. (2012). Changes in belief orientations of preservice teachers and their relation to inquiry activities. *Journal of Science Teacher Education, 23*, 909–936.

Plevyak, L. H. (2007). What do preservice teachers learn in an inquiry-based science methods course? *Journal of Elementary Science Education, 19*(1), 1–13.

Qualifications and Curriculum Authority (QCA). (2013). Scientific and technological understanding: programme of learning, UK. Retrieved from https://www.gov.uk/government/publications/national-curriculum-in-england-science-programmes-of-study.

Riggs, I., & Knochs, L. (1990). Towards the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education, 74*, 625–637.

So, W. W. M. (2008). Primary science learning of Hong Kong through the lens of TIMSS. *Asia-Pacific Forum on Science Learning and Teaching*, *9*(1), Article 16 (June, 2008). Retrieved from http://www.eduhk.hk/apfslt/.

So, W. W. M., & Watkins, D. (2005). From beginning teacher education to professional teaching: a study of the thinking of Hong Kong primary science teachers. *Teaching and Teacher Education, 21*(5), 525–541.

Supovitz, J. A., & Turner, H. W. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of Research in Science Teaching, 37*, 963–980.

Swain, J., Monk, M., & Johnson, S. (1999). A comparative study of attitudes to the aims of practical work in science education in Egypt, Korea and the UK. *International Journal of Science Education, 21*(12), 1311–1323.

Tabachnick, B. G., & Fidell, L. S. (2001). *Using multivariate statistics* (4th ed.). Needham Heights: Allyn & Bacon.

Thomas, G. P. (2003). Conceptualisation, development and validation of an instrument for investigating the metacognitive orientation of science classroom learning environments: The metacognitive orientation learning environment scale—science (MOLES-S). *Learning Environments Research, 6*(2), 175–197.

Trends in International Mathematics and Science Study (TIMSS). (2011). Science assessment framework. Retrieved from http://timssandpirls.bc.edu/timss2011/downloads/TIMSS2011_Frameworks-Chapter2.pdf.

Tsai, C. C. (2002). Nested epistemologies: science teachers' beliefs of teaching, learning and science. *International Journal of Science Education, 24*(8), 771–783.

Van Aalderen-Smeets, S. I., Van Der Molen, J. H. W., & Asma, L. J. F. (2012). Primary teachers' attitudes toward science: a new theoretical framework. *Science Education, 96*, 158–182.

Varma, T., Volkmann, M., & Hanuscin, D. (2009). Preservice elementary teachers' perceptions of their understanding of inquiry and inquiry-based science pedagogy: influence of an elementary science education methods course and a science field experience. *Journal of Elementary Science Education, 21*(4), 1–22.

Wong, N. Y. (2004). The CHC learner's phenomenon: its implications on mathematics education. In L. H. Fan, N. Y. Wong, J. F. Cai, & S. Q. Li (Eds.), *How Chinese learn mathematics: perspectives from insiders* (pp. 503–534). Singapore: World Scientific.