Chinese Secondary Physics Teachers' Beliefs and Instructional Decisions in Relation to Inquiry-based Teaching

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Abstract

This paper reports case studies of five Chinese secondary physics teachers' beliefs and instructional decisions in relation to inquiry-based teaching (IBT). It is part of a larger study intended to explore Chinese secondary physics teachers' beliefs and the ways in which their beliefs influence their classroom practices in the context of the current Chinese science curricular reforms around inquiry-based teaching. The study employed in-depth semi-structured interviews, classroom observations, informal conversations and field notes to explore teachers' beliefs and instructional practices. A range of beliefs the five teachers held about the nature of science and physics, teaching and learning, and inquiry-based teaching exerted a complex set of influences on teachers' instructional decisions. Their perceptions of 'what counts' as effective teaching seemed to be the predominant influence. These beliefs and their influence on teachers' instructional decisions should be understood within the current Chinese teaching context within which these teachers were working. They were pressed for time and were under high pressure to prepare students for the College Entrance Examination. They were attempting to teach a reformed, inquiry-based curriculum in a system lacking a complementary assessment system. These conditions are mirrored in many other education systems in the region and the world in which inquiry-based teaching is mandated, and the cases presented here contribute to the development of richer understandings of teachers' take-up of curricular reforms.

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Introduction

Inquiry-based teaching is an influential foundation for curricular reforms in science education in many educational jurisdictions throughout the world (Abd-El-Khalick et al., 2004). Evidence suggests (Anderson, 2002; Campbell, Oh, Shin & Zhang, 2010) that teachers all over the world struggle to implement inquiry-based changes to their teaching practices. This paper contributes to knowledge in international science education by reviewing a number of Chinese studies, including some not available in English, and by offering deeper and more detailed insights into the complex sets of reasons why teachers do or do not adopt inquiry-based teaching in their classrooms. It is intended as an antidote to 'blame the teachers' approaches and simplistic reactions: the professional decision-making on the part of these teachers is sophisticated, intended to serve their students learning and best interests and based in their constellations of beliefs about students, science, knowledge, learning and teaching.
'Inquiry' refers to an intellectual process through which students develop understanding of scientific ideas and the ways in which scientists study the natural world (NRC, 1996) through

actively engaging with scientific questions and investigations. Although what is seen as constituting inquiry in science instruction varies widely across the literature (Anderson, 2002), the essential characteristics of classroom inquiry (NRC, 2000) include offering opportunities for students to:

1. Identify scientific questions;
2. Design and conduct a scientific investigation;
3. Use appropriate tools to gather, analyse, and interpret data;
4. Develop descriptions, explanations, predictions, and models using evidence;
5. Think critically and logically;
6. Consider alternative explanations; and
7. Communicate scientific procedures and results.

According to the US National Science Education Standards (NSES) (NRC, 1996), inquiry is not only a learning goal but also a teaching method. To that end, importance is attached to inquiry-based teaching (IBT). This is reflected in the content and teaching standards in the National Science Education Standards. Following the United States, other western countries' science curricula have begun to devote attention to IBT.

The recent Chinese reforms to the national science curricula also attached importance to IBT. These reforms advocated "a variety of other learning activities such as active participation, exchange and co-operation, exploration and discovery to enable the students to become independent learners", and stated that "learning science should be a hands-on experience, where the student actively deploys his scientific knowledge" (Poisson, 2001, p. 17). These objectives were emphasised in all school science subjects' curriculum standards, which identified IBT as an essential teaching method to target these objectives. Consequently, teachers were strongly encouraged to use IBT in their classrooms to teach science.

Many Chinese science teachers found it very challenging, however, to implement inquiry-based teaching (IBT) in their classrooms (Zhang, Meng, Gao, Li & Xin, 2003). IBT requires teachers to change not only their ways of teaching physics but also their beliefs. Teachers have to adapt their existing belief systems to accommodate the philosophical underpinnings of IBT. As a large amount of research has pointed out, belief structures play a major role in teacher decision-making about instructional tasks (Nespor, 1987; Pajares, 1992; Richardson, 1996). Changing teachers' beliefs, however, is not easy. Nespor suggests that changing peoples' beliefs is tantamount to changing who they are as individuals (Nespor, 1987), because beliefs provide personal meaning and assist in defining relevancy (Pajares, 1992). For teachers, beliefs are particularly important as frameworks to make sense of the context in which they work, because "many of the problems they encounter are ill-defined and deeply entangled" (Nespor, 1987, p.324).

Researchers and educational leaders have exerted considerable effort to convince teachers to try IBT. Little research effort, however, has been devoted to teachers' beliefs and the association between these beliefs and teachers' instructional decision-making in their unique classroom contexts. Although some studies have emphasised the importance of transforming teachers' beliefs for successful implementation of IBT (e.g. Liu, 2008; Yang, 2002), very little research has investigated teachers' beliefs in relation to their practice. It seemed there was a big piece missing in educational researchers' 'map' when it came to understanding reasons for teachers' reluctance to take up the inquiry modes mandated in the new curricula.

Given this situation, this study is designed to address the following research questions:

1. What beliefs do Chinese physics teachers hold about
   a. the nature of science?
   b. teaching and learning science?
   c. the nature of inquiry-based teaching (IBT)?

2. How do Chinese teachers
   a. perceive the changes in the curriculum?
   b. interpret inquiry-based teaching (IBT)?
   c. implement IBT in their teaching?

3. What are the associations between teachers' beliefs and their instructional practices regarding IBT?

The answers to these questions are significant in attempting to understand the processes that support and constrain the implementation of IBT in Chinese secondary physics classrooms. This study is expected to add to the existing body of literature on IBT by exploring Chinese physics teachers' perspectives. These results will also be relevant for educators in the many other countries attempting to implement inquiry-based curricular reforms in science education.

Literature Review – Teachers' Beliefs and Instructional Practices

Teacher beliefs about the nature of science and teaching and learning science

A large body of research has shown that belief structures play a major role in teacher decision-making about instructional tasks (Nespor, 1987; Pajares, 1992; Richardson, 1996). Prior research has shown that teachers' beliefs about the nature of science, acquisition of knowledge, the curriculum, teaching and learning science, students and themselves, and the teaching context impact teaching practices.

Studies have found that many teachers perceive school science knowledge is a prescribed set of facts, principles, and concepts to be transmitted by the teacher and memorized by the students (Gallagher, 1991; Pope & Gilbert, 1983; Tobin & McRobbie, 1996). These conceptions on the part of teachers can be significant obstacles to implementing inquiry-based teaching. For example, science teachers who held such views were found to pay little instructional attention to the process of obtaining scientific knowledge (Gallagher, 1991). Science teachers with absolutist views of truth and knowledge tended to pay little attention to students' conceptions during instruction (Pope & Gilbert, 1983).

Some studies also reported that many teachers tended to see science as an objective body of knowledge created by a rigid scientific method (Brickhouse, 1990; Duschl & Wright, 1989; Gallagher, 1991). These beliefs were found to inhibit teachers' attempts to involve students in inquiry activities (Wallace & Kang, 2004).

In contrast, teachers with constructivist beliefs were found to recognize students' prior knowledge and use variable teaching strategies to develop students' conceptual understanding (Heshweh, 1996). Teachers who believe that factual content acquisition is the most important student outcome and that students learn best through repeated drill and practice were found to be unable to enact a constructivist-based curriculum in the ways that the developers intended (Cronin-Jones, 1991). In contrast, teachers who believed that their students had the cognitive capacity to process the learning goals set forth by the mandated curriculum and set by the teachers accomplished more meaningful inquiry activities (Wallace & Kang, 2004)

Teacher beliefs about inquiry instruction

In relation to inquiry, research has demonstrated that teachers have variable understandings (Crawford, 2007; Keys & Bryan, 2001; Wallace & Kang, 2004). Therefore, teachers may have false conceptions (Anderson, 2002) or incomplete understandings of inquiry (Crawford, 2007). Some may view inquiry-based teaching as consisting of cookbook type activities through which students will successfully find the correct answers by following well-defined steps. It is not surprising that teachers' (mis)interpretations of inquiry could impede their implementation of IBT and shape the way IBT is conducted in teachers' classrooms.

Relationship of teacher beliefs to instructional practices

Although teachers' beliefs were found to be related to their instructional practices, research indicates that this relationship is not unidirectional (Levitt, 2001; Munby, Cunningham & Lock, 2000). Teacher's instructional practices can modify or reinforce their beliefs. For example, Levitt (2001) showed that beliefs and practices of the teachers in his study changed in a reciprocal way through implementation of new curriculum models. Tobin and McRobbie (1996) have pointed out that teachers make sense of their teaching roles in terms of cultural 'myths', which are related to teachers delivering knowledge, being efficient, maintaining the rigor of the curriculum and preparing students to be successful on examinations. Munby et al. (2000) suggested that the nature of school science influences how teachers assess their own teaching. They argue that the tacit cultural values in schools inevitably shape teachers' perceptions of themselves and their classes, and in turn influence teachers' instructional decisions.

Earlier studies around inquiry-based teaching in China

Many Chinese scholars writing in the field of curriculum and instruction have attempted to find a solution to the problem of the limited uptake of IBT by teachers by focusing on theory. For example, there are many articles discussing different aspects of IBT, such as the psychological basis of IBT, strategies to implement IBT, differences between IBT and other approaches and development of social resources and school management for IBT (e.g. Tao, 2002; Zhang, 2000). On the other hand, the amount of research grounded in real classroom contexts, either qualitative or quantitative, is relatively small. Some studies looked into classroom practices using quantitative (survey) methods. One typical research project was a quantitative survey of students (Huang, 2003), which was mainly used to explore students' perceptions of inquiry-based learning. Another typical method was experimental studies using an experimental group and a control group, who were taught using IBT and traditional approaches respectively (e.g. An, 2004; Deng, 2006; Jiang, 2004; Wu, 2006). In these studies, the researchers employed pre-test and post-test measures to compare students' test scores before and after teachers' implementation of IBT (experimental) and traditional (control) approaches.

The present study falls into an area that is almost entirely unresearched: close-grained qualitative research at the classroom level focusing on teachers' beliefs and practices in the classroom, and how those beliefs and practices interact. It sheds light on teacher resistance to the implementation of inquiry-based curricular reforms in China and internationally, and is timely because such reforms are being rolled out – and resisted – in science education classrooms all over the world.

Context of the Study

The study took place in Shanghai, a major city in the eastern part of China. Shanghai was chosen for this study mainly due to its superior economic conditions and better educational resources than other regions of China. In addition, prior to the national curriculum reform, in 1992 and 1998, Shanghai was required by the former State Education Commission (now the Ministry of Education (MOE)) to initiate its first and second round of curriculum reforms respectively (see, Shanghai Municipal Education Commission (SHMEC), 2005), which meant that schools in Shanghai had a 'head start' in implementing inquiry-based teaching compared with schools elsewhere in China. The new senior secondary curriculum standards and textbooks were used in all schools from 2006. IBT was introduced to the curriculum standards from then on. Due to these reasons, research on teachers' inquiry-based teaching in Shanghai can be compared with earlier studies done in western countries. It is also well positioned to inform the reform processes in the rest of China as the IBT reforms spread more broadly across the nation.

Method

The larger study, from which the five teacher case studies reported in this article came, was a mixed methods (Tashakkori & Teddlie, 2003) study that included quantitative surveys of ninety-nine senior physics teachers from three similar districts[1] of Shanghai, China. The larger study collected and analysed information on senior secondary physics teachers' beliefs and their instructional practices, including surveys, interviews, informal conversations, classroom observations and field notes. The study reported in this paper is a closer-grained qualitative analysis of five teachers, selected in order to represent a range of contexts and levels of teaching experience. A case study methodology (Flyvbjerg, 2011) was chosen for this smaller study in order to focus closely on five specific teachers and their beliefs and practices in relation to IBT.

Flyvbjerg (2011) notes that "case study produces the type of concrete, context-dependent knowledge that research on learning shows to be necessary to allow people to develop from rule-based beginners to virtuoso experts" (p. 302). In an earlier book (Flyvbjerg, 2001) he makes the broader argument that, in the social sciences, broadly generalised, context-independent, rule-based knowledge is necessary but not sufficient for expertise. Rules are an appropriate starting place for novices, but true expertise in the human realm requires understanding of multiple concrete, contextual cases.

The cases presented in this study are intended to offer rich, contextual explorations of the beliefs and practices of particular teachers in particular classrooms, as 'occasions for reflection' (Geelan, 2004, p. 4) on the part of readers, who are assumed to be experts in the field of science education, as well as 'empirical materials' (Denzin & Lincoln, 2005, p. 25) to inform their thinking about the implementation of inquiry-based teaching.

Participants

The five senior secondary physics teachers who participated in this study were selected from four different school types and had different lengths of teaching experience. All

[1] There are no major differences among these districts or between these districts and other districts in Shanghai in terms of educational resources.

the teachers taught Year 10 physics in the same district of Shanghai. All the teachers held at least a bachelor degree in physics education. The five participants, who had different levels of teaching experience, were selected in order to provide information about teacher' beliefs at different career stages. The rationale for this selection was based on findings that experienced teachers and beginning teachers tended to have different beliefs about, and approaches to, teaching science, along with different attitudes towards curriculum reform and different trends in belief change (Luft & Roehrig, 2007; Wallace & Kang, 2004). In addition, teachers working in different types of schools may also tend to hold different beliefs. Information on the five participants is given in Table 1[2].

CODE	Gender	Degree	Teaching experience	School Type	Year level
Mr. Lu	Male	Bachelor	27 years	Municipal key school	Year 10
Ms. Ding	Female	Bachelor	11 years	Municipal key school	Year 10
Mr. Zhao	Male	Master	18 years	District key school	Year 10 & Year 12
Mr. Hao	Male	Bachelor	20 years	Normal public school	Year 10
Mr. Min	Male	Master	4 years	Private school	Year 10

Table 1. The five participants in the case studies

Data collection

Interviews. Semi-structured interviews were conducted individually with teachers to probe their beliefs about, and instructional decisions regarding, IBT. To fulfil this aim, the questions were designed to be related to teachers' beliefs about the nature of science, physics and physics curriculum, their perceptions of teaching and learning, and their interpretation of inquiry-based teaching (IBT). Teachers, however, were free to pursue any topic relating to their teaching of physics. Each interview lasted 50-60 minutes. All interviews were audiotaped and then fully transcribed. Analysis was conducted in Chinese and then significant quotes translated into English.

Classroom observations. The teachers' classrooms were observed during one school semester (from September 2009 to January 2010) to record the details of their instructional practices in relation to IBT. Classroom observations were arranged according to teachers' convenience and teachers were told that the researcher would prefer to observe classes which dealt with several topics if it was possible and practical to do so (so teachers were possibly compared with each other if they taught the same topics). Informal conversations were conducted and recorded before or after the observed lessons. Field notes were also recorded. Each teacher was observed three to five times[3]. The researcher sat at the back of the classrooms and acted as a non-participant observer. An observation schedule that focused on teachers' inquiry-based instruction was developed for this study. Each observation lasted for the duration of the lesson, ranging from 40-50 min.

Informal conversations and field notes. Informal conversations were conducted before and

[2] Teacher and school names are pseudonyms.

[3] Classroom observations were arranged according to teachers' convenience and the topics teachers selected to teach.

after classroom observations with teachers to better understand teachers' instructional practices regarding IBT. Questions were asked in relation to specific teaching and learning activities seen in the classroom observations. For example, after one lesson on "The Resultant of Forces" Ms. Ding was asked; "Why did you use a new teacher demonstration, instead of the one in textbook, to explain the parallelogram rule?", and "How did you decide to use this demonstration?" These informal conversations were audiotaped when it was possible to do so; otherwise they were recorded in the researcher's field notes after the school visits. The researcher also used field notes to record teachers' instructional practices during classroom observations.

Data analysis

This study employed an interpretive approach (Berg, 2004) to analyse data. The interview analysis focused on meaning (Kvale, 2007) in order to capture the participants' own meanings and points of view. Interview transcripts were used to identify meaningful themes (Glaser & Strauss, 1967) with respect to teachers' beliefs and their instructional practices regarding IBT. These themes were then grouped into core categories (Tobin, 2000) which were concerned with teachers' perceptions about (1) the nature of science, (2) teaching and learning physics, (3) teaching context, (4) inquiry-based teaching, and (5) instructional decisions regarding IBT.

Since all the teachers were physics teachers, when discussing their beliefs about the nature of science, they always linked these beliefs with the subject matter. Therefore, teachers' beliefs about the nature of science and the nature of physics were categorised into the same theme.

While some research traditions such as grounded theory (Strauss & Corbin, 1998) tend to draw themes from qualitative data inductively, this is not the only available approach. Braun and Clarke (2006) outline inductive, deductive and mixed approaches to thematic analysis of qualitative data. The present study used a deductive approach, seeking data relevant to the themes identified in the research questions, while also seeking discrepant cases and disconfirming evidence.

Data from classroom observations were initially coded according to the features of teachers' instructional practices regarding IBT. For example, the degree to which teachers structured what students did was referred to as "guided", "open-ended", or "teacher-collaborative" [4] inquiry. Secondly, teachers' instructional practices were coded in relation to the five essential features of classroom inquiry and their variations (NRC, 2000), for example, "Learner engages in a question provided by the teacher, materials, or other source".

Information obtained from analysing interviews and observations of classroom practices was then combined to associate teachers' beliefs with their instructional decisions regarding IBT. Informal conversations and field notes were used as additional support for understanding the relationships.

Results

This section of the paper presents the individual case studies of the five teachers in relation to the research questions about teacher beliefs, instructional decisions and instructional practices. While the section of the paper following this one summarises some

[4] Teacher's role was defined as a co-researcher in student's investigation.

commonalities and themes, these cases represent the ‘findings’ of the study to at least the same extent. Readers are encouraged to consider each case individually in terms of the light it sheds on teachers’ complex sets of beliefs and practices, and their interactions, and then to consider the various ways in which the cases resonate with one another. The differences between cases are, after all, at least as important as their similarities when it comes to richly understanding the context-bound activities of real teachers in real classrooms.

Mr. Lu

Mr. Lu was a very experienced teacher with 27 years teaching experience. He taught in School Phoenix. School Phoenix was one of two municipal key schools[5] of this district. This school was publicly considered to be one of the top schools in Shanghai and enrolled a large number of senior secondary students.

Beliefs

Mr. Lu suggested that the nature of science was to discover the rules of nature. He perceived senior secondary physics as a model-based subject that required students to “use idealization to construct scientific models”. “Some of the models, however, were difficult for students to imagine, they therefore turned into rote memories”, he stated. Therefore, he claimed that “whichever strategy teachers employed was to help students construct physics models”.

In addition, in order to construct physics models, it was necessary to exclude some secondary or minor factors (from the observed phenomena) to form near-ideal situations. However, “this process was impossible to occur naturally in real life and thus it was very difficult for students to do experiments without teachers’ excluding the external disturbance in advance”, he argued. Meanwhile, because “it was very difficult to exclude secondary or minor factors (from experiments)”, inquiry activities “were limited by many conditions and difficult to complete (in the laboratory)”. Therefore, he insisted that “what teachers actually did (using experiments) was to validate conclusions” and “it was impossible for students to discover an unknown rule” (in experiments).

Regarding his students, Mr. Lu was concerned about his students’ learning habits and interest. He reported his students did not have good learning habits and did not know their own needs.

> … We feel our students are not diligent in fact, and not smart - as they do not understand their own first need. That is, they only learn when the teacher forces them. I feel there are very few students learning actively. To tell the truth, they learn for the College Entrance Examination (CEE).
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> Students themselves do not know their direct[ion] of learning. They want to save trouble, and want to shirk work. If the teacher does not give them assignments, they certainly will not do their jobs. I feel there is no one who knows what he needs.

Mr. Lu claimed that interest can help students to learn physics well. However, he realised that his students did not have an interest in learning physics.

> Learning today, I feel, is a kind of forced learning. …It is a kind of learning without considering students’ own will. Students are forced to learn by their parents, teachers and the society. Therefore they really do not have fun in learning.

[5] Key school: The key schools have advantages in enrolling students and obtaining educational input over the normal public schools.

For this situation, Mr. Lu felt very regretful. As a teacher, he perceived himself as an accomplice of parents to force students to learn. However, he felt there was no better way to solve this problem, as the CEE acted as a “baton” conducting all teachers’ work and the teachers had to “live at the present”. Therefore, he held that students should obtain correct knowledge and answers; otherwise they would fail the exams. And if they did not understand well, they should do more exercises, besides being given teachers’ instructions. What teachers did, therefore, he considered, was “racking their brains to make students to master knowledge”.

With respect to inquiry-based teaching (IBT), Mr. Lu tended to equate students’ inquiry to reproducing scientists’ work. For him, inquiry provided a way to experience the formation of knowledge, and know the source of knowledge. However, he argued that “it was an impossible task for students to replicate prior scientists’ work and reorganise those rules”. He therefore felt that IBT was difficult to implement in laboratories. In addition, although he commented that IBT was a good teaching approach, he seemed not to feel confident to implement IBT. As he said, “I was not competent to do so, frankly speaking. And I did not find good approaches to conducting IBT”.

Instructional decisions

Mr. Lu decided to use a lecture-style method to teach physics as he felt the most important thing for students was to master knowledge and obtain the rules of the nature and indicated this way was right for him.

> I don’t think there is a unified standard (for teaching). The main point is that we feel comfortable with the way we teach….As soon as we feel comfortable, and that students have grasped the knowledge, basically, this approach, I think, is the best. There is no fixed approach to teach, but proper approaches.

Although he thought IBT could benefit students’ learning, he decided not to apply it to his classrooms. In addition, he reported he decided not to carry out too many hands-on activities in his classroom because he felt that there was no time for doing these activities and hands-on activities were not assessed by the CEE. He claimed he had never implemented IBT before, “(My teaching) is lecture-style teaching, or to complete a certain amount of teaching task… This does not allow me to implement IBT”.

Instructional practices

Mr. Lu’s claim that he did not implement IBT in his classrooms was largely borne out by the observations. He tended to employ a lecture mode of teaching in classrooms. He seldom asked students questions. Sometimes he asked a few questions but did not expect students to answer because he immediately answered them himself. Mr. Lu sometimes used Powerpoint slides in his lessons, which, however, were treated as prewritten notes rather than an apparatus for demonstration.

However, several features of inquiry-based instruction were observed in laboratories when he brought students to do student experiments. He gave students scientific questions in the laboratory, directed them to collect certain data, and showed them how to analyse the data to reach a conclusion.

Ms. Ding

Ms. Ding taught in School Phoenix as well. She had been working as a teacher for 11 years. Besides teaching duty, she also undertook a position as the coordinator of the physics department of this school. Ms. Ding was publicly recognised as an excellent teacher in this district.

Beliefs

Ms. Ding regarded science as a knowledge system accurately reflecting the rules of nature. Because of this perception, she emphasised the "systematicity" and "veracity" of the knowledge students learned. This was reflected in her views about the reformed curriculum, textbook and student experiments. For the reformed curriculum, she stated that,

> Although we have the new curriculum[6], it is difficult to implement at Year 10 and Year11 level, because we do not divide students [who want to study Year 12 physics from those who do not]. All students learn together. In this situation, if… we treat [the] extension part as [an] elective course, there emerges a problem: a problem of link between the basic and extension parts….If we separate the two parts, it would affect students on their formation of knowledge system and teaching efficiency as well.

For the reformed textbook, she pointed out that,

> Deleting some content (from the earlier version of [the] textbook)… made students' knowledge system incomplete.

She felt, therefore, that she had to cover those deleted topics and the content in the extension part in order to let students link knowledge together to form a complete knowledge system. She also stressed the importance of achieving the "correct conclusion" in student experiments and claimed that,

> Although you can argue that students are inquiring about a (physics) rule in [the] laboratory, conclusion is more important in most cases, because this rule is the one that students have to master. Should they trust the knowledge in the textbook, or not, when they did not get correct conclusion? They would be suspicious of the veracity of the knowledge system. This was absolutely not allowed in senior secondary education.

In this sense, Ms. Ding regarded the main purpose of current experiments as being to validate the conclusions, because "the topics and contents of experiments have already been set forth (in the textbook)".

Considering her students, Ms. Ding felt her students did not have good thinking habits and held somewhat utilitarian views of learning.

> I particularly feel the students seem to be overimpatient. This gives me a headache. They want instant solutions rather than thinking deeply. They prefer to be told a conclusion and copy it down. This is their way to learn, and I feel it is a nuisance.

> They learn for solving physics problems, but seldom think why this concept has to be defined in this way and why there are such rules of physics.

For these students, Ms. Ding claimed effective teaching should "inspire students' interest first" and then "help students develop a good and open thinking model".

Ms. Ding's perception of effective teaching was consistent with her understanding of IBT. In her opinion, IBT was a kind of teaching activity which "allowed students to independently finish one section of a learning task (one or two concepts) following their own thoughts". Therefore, inquiry could "foster students' interest very well" and through experience of inquiry, students "applied, reflected on and understood process and methods". "With these processes and methods integrated in their minds", she suggested, "Students tended to be more flexible in their perspectives when thinking problems". Due to her understanding of IBT, Ms. Ding suggested that IBT could be implemented in one section of a lesson.

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[6] The new physics curriculum consists of three parts: basic part, extension part and research part. For students who do not want to choose physics at Year 12 level, they only need to learn the basic part. Others have to learn both the basic and extension parts. Teachers normally do not teach the research part.

However, Ms. Ding's perceptions of IBT did not mean that she disapproved of lecture-style methods of teaching. For her, IBT was better in helping students to "grasp the process and methods" which she described as students' long-term interests, while lecture-style teaching may be more practicable in helping students "master knowledge and skills" which she regarded as students' immediate interests. Furthermore, she pointed out that currently teaching and learning are confronted with an assessment regime which "used written tests as a main tool", while "written tests relied more on experience in drills training to solve problems". Therefore she perceived that "IBT was not in consonance with tests". This indicated that Ms. Ding was more convinced by the effectiveness of lecture-style teaching to improve students' test scores in a test-oriented assessment system. She stated that it was hard for teachers to handle the relation between teaching for students' immediate and long-term interests in the current teaching context.

Instructional decisions

Ms. Ding was keen to use inquiry-based teaching (IBT). She claimed that she had implemented IBT many times. In addition, she proposed two forms of classroom inquiry: general inquiry based on experiments and hands-on activities, and "speculative inquiry", which did not need experiments. She suggested that IBT could be conducted in a form of "speculative inquiry" in two situations:

> The first situation is concerned with thinking, for example, concluding problem-solving methods, comparing models, summarising the applicable conditions of rules, and etc. The second one is with respect to teaching of some theorems, such as the kinetic energy theorem, the momentum theorem and ideal gas equation. These theorems were able to be deduced from prior knowledge.

With these two forms of inquiry, she argued that inquiry could be "infiltrated" into any type of lesson including exercises lessons, provided "the teacher held clear teaching objectives". However, she insisted that IBT had to be implemented on the prerequisite that students were able to form a correct knowledge system.

Meanwhile, she considered that there were risks when implementing IBT because of the lack of consonance between IBT and tests. As students were finally assessed by examinations, "some content (of the syllabus)… had to be mastered by all students". Even in inquiry activities, she suggested that "it is acceptable to use IBT, but students have to achieve the same conclusion".

In addition, she indicated that she wanted more support from other teachers' cases of conducting IBT. She proposed that,

> There should be someone, who is implementing inquiry-based teaching, and then whose students develop their abilities, exhibit their own advantages, and score high in tests as well. So (teachers are convinced). I should say that most teachers would like to ensure their students' long-term interests, for conscience' sake. Right? Therefore there must be many more such cases showing that both student' immediate and long-term interests are guaranteed.

Instructional practices

In Ms. Ding's classrooms, she created more classroom demonstrations than required by the textbooks. She probed students' prior knowledge by asking different levels of questions. She required students to think about the evidence she collected from classroom demonstrations and put forward explanations. She responded to students' answers and contrasted them with her explanation. In the laboratory, she gave students scientific questions, directed students to collect the required data, and required students to achieve the "correct" conclusions. Students were not required to formulate and judge their own explanations.

It seemed that Ms. Ding provided students with a "well-organised" experience of inquiry under her strong control over the class. In this situation, students did not have opportunities to propose their own questions, engage in their own investigations, collect their own evidence and adjust their alternative explanations.

Mr. Zhao

Mr. Zhao taught in School Crane. It was a moderately-sized district key school in this district. This school was publicly recognised as one of the good schools, although not as excellent as the municipal key schools, in this district. Mr. Zhao had taught physics for 15 years and held a masters degree in physics education. Besides teaching, he was concerned about educational theories and had written some journal articles.

Beliefs

Mr. Zhao demonstrated a set of competing beliefs. About the nature of science and physics, on the one hand, he perceived science as "explanations to objective phenomena. It was therefore objective". "However, not everything could be explained", he stated, "Some knowledge was uncertain. Some rules were just something (accounting for) facts or events whose possibility of recurring was greater than others".

On the other hand, Mr. Zhao tended to conceive of science as a body of knowledge that students needed to acquire and teaching as imparting knowledge to students. It is therefore not surprising that when discussing his ideas about effective teaching, Mr. Zhao stated that the conventional teaching approach - lecture-style teaching - was a highly effective approach to teaching, although it was not able to satisfy all teachers. As he argued,

> We have tried whatever we can to teach during the last several decades. Why [do] we still choose such a teaching approach that could not satisfy all of us? It is thus clear that this teaching approach is not only effective but also highly efficient. Compared with others, it had a "lower input" but with a "better outcome".

Corresponding to his opinions of teaching, he referred to learning as a process of grasping knowledge. Therefore, he emphasised the importance of "*variant training*"[7], meaning a large amount of exercises with different forms. In his opinion,

> If students' knowledge was declarative, students could not recognize the problem situation this knowledge applied to. Only when their knowledge was procedural, students could use the knowledge automatically.

In order to achieve this purpose, he insisted that students needed "*variant training"*, through which their knowledge turned from declarative to procedural, and then they were able to achieve better results in the exams. Mr. Zhao said he did not have such a belief a couple of years ago. He stated that he had changed his opinions since he found that his students' test scores were always lower than those of other teachers' students who had a large amount of drill training.

Mr. Zhao showed more conflicting beliefs regarding education. On the one hand, he attached the highest importance to "student thinking" and suggested "developing ability was more important than gaining knowledge". On the other hand, he suggested that "the major purpose of imparting knowledge was to pass on culture" and "students were carriers of social culture". In this sense, he argued that "students took more responsibility for this social role than their individual roles". Developing ability, for example, he regarded as one of students' individual roles, which, however, "relied more on students themselves".

[7] These are the teacher's original words.

In relation to IBT, Mr. Zhao also had a set of competing beliefs. On the one hand, he asserted that "IBT could be any teaching and learning activity as long as it fostered students' thinking". On the other hand, Mr. Zhao did not believe the student experiments in the textbook were appropriate for conducting IBT, because he felt that "their purpose was to develop student experiment skills and to meet the requirements of the examination".

Mr. Zhao claimed that students could feel "uncertainty" about science knowledge through inquiry because "the results of science inquiry were highly uncertain". On the other hand, he pointed out that this was not consistent with the current teaching context. Because "our 'school factories' only want to manufacture one kind of standard product (students with high test scores)", as a consequence, "what students want to pursue is only the answers".

Mr. Zhao admitted that inquiry could benefit students' future lives. He, however, doubted the effectiveness of IBT for enhancing students' achievement in the future. He stated,

> If we teach students using inquiry through basic education, I think that students would not necessarily be admitted to a first-class university… and it is a question whether they would develop into excellent people in the future.

In addition, he was very sceptical about the usefulness of IBT in a Chinese context that emphasises high-level academic training. This suspicion resulted from his distrust of the applicability of "imported theories" to the Chinese context. As he put it,

> …Teaching in the United States seems to give more consideration to individuals, and does not to force students to learn something…The students (in the U.S.) have choices. In this situation, those teaching strategies or approaches (e.g. inquiry-based teaching) may be effective to improve students' academic achievement. However, I doubt how useful these things are, in the Chinese context that emphasises high-level academic training.

Furthermore, Mr. Zhao held a very pessimistic view of the larger social context in which teaching occurred. He asserted that it was impossible to use IBT to cultivate students' creativity or independence in the current social situation. He attributed students' passivity and lack of creativity to the consequence of school academic training, which was seen by him as endemic in this country, and felt that teachers could only passively react to it. He commented,

> What we are doing is try something new in a very limited space. These… are not fundamental solutions.

> I think, in our country, it is almost impossible to use IBT to foster students' "sense of creativity", or independent ideas. I could not see there is a time point when things can change. We cannot make it. It is fundamentally the problem of the country system.

Meanwhile, Mr. Zhao indentified IBT as neither effective nor efficient. He felt it was not realistic to implement it in day-to-day teaching, as "teaching task was difficult to complete if using IBT in a whole lesson". In addition, he stressed that the existing school assessment criteria did not assess student understanding of process and methods, and thus students' learning outcomes in IBT were hard to assess, and the teacher may be misunderstood because their students' scores were not high enough.

Instructional decisions

Mr. Zhao was very concerned about the efficiency of teaching approaches. He indicated that he would continue to use the approach of lecture-style teaching.
He also suggested that students needed more "variant training". He concluded, "Although this may not be the best method, it may be most efficient method (to grasp knowledge and improve students' test scores)".

But Mr. Zhao was against purely using lecture-style teaching. He hoped that his students could also develop some abilities that could benefit students' future lives. He was concerned about the situation that encouraged excessive use of the lecture-style approach to teaching. He affirmed,

> If students are taught by our way – pure lecture and unending drill training afterwards - what they have learned in high schools will totally disappear in a couple of years. This kind of education is useless.

Therefore, Mr. Zhao hoped to "give consideration to both" students' test results and developing their abilities. He claimed that he was actively trying IBT. However, he decided to use his own way, a method to offer his students vicarious experience of inquiry: let students experience inquiry through knowing the process of others' inquiry but without directly participating. In a word, Mr. Zhao modified the concept of IBT to fit in with his belief system.

Instructional practices

Mr. Zhao told students stories of scientists who worked to find the rules of nature, how they inquired about physical situations and what kind of problems they might encounter during inquiry. Although Mr. Zhao claimed that this is his (vicarious) approach to IBT, it may not be a real approach to inquiry. However, several features of classroom inquiry were identified in his teaching, but he himself may not realise, or consider, these elements to constitute IBT.

In his classroom, Mr. Zhao probed students' prior knowledge by asking questions. He provided students with problems and required students to solve these questions. Sometimes he used Socratic questioning to challenge students' thinking. He required students to think about the explanations he put forward. He asked students toevaluate other students' work and find the mistakes. He also directed students to follow steps to collect certain data and analyse them in the experiments. However his students were seldom required to work cooperatively to solve problems and communicate their ideas.

Mr. Hao

Mr. Hao was an experienced teacher and had been teaching for 19 years. Mr. Hao taught in School Peacock. School Peacock was a normal public school of moderate size. This school enrolled students who reached the cutoff score of the public schools but had lower test scores in the senior secondary school entrance examination (SSSEE) than those of the key schools.

Beliefs

Mr. Hao stated that physics was a science subject based on phenomena and experiments. He therefore felt that experiments were very important to teaching and learning physics. "Without experiments they (teaching and learning) produce little effect, and lose contact with reality", he asserted. The functions of experiments, for him, were "to experience physics, reinforce students' manipulative skills, and grasp the method of scientific inquiry".
In Mr. Hao's opinion, the best physics learners could follow the textbook to study, solve problems and do experiments on their own, and could finally achieve a good quality of understanding and a good academic result as well. For this reason, Mr. Hao did not like the reformed textbook because "it was hard to read and follow for students".

His current students were obviously seen as not being this kind of physics learners. Mr. Hao felt his students had low motivation and ability to learn. As he stated,

> Our students' basic abilities to study were low, and they had problems in learning habits and obeying school discipline.

> They (my students) only have this much ability that you can only teach them this much. Too much won't work, and too little is meaningless.

> They (my students) do whatever the teacher tells them, and they dare not have ideas. In addition, they do not have ideas, and do not know how to think.

Mr. Hao also tended to perceive most students as passive learners regardless of their schools' types.

> And for those students in the key schools, I can say, their ideas are simply like that as well, 'the teacher told me that. I therefore follow the teacher's steps". They are just better (than my students) in grasping more what teachers told them.

He therefore stressed that the students should carefully listen to their teachers' instructions and copy the teacher's notes. In addition, he emphasised the importance of repeating exercises after class to achieve higher test scores,

> It does not mean (students) can solve problems when they take my notes. They need repeated practices afterwards. This section cannot be omitted, just like thousands and millions of times of drills training for a gymnast.

Consistent with this perception, Mr. Hao claimed that the teacher's role was "spoon-feeding students with teachers' ideas". Teachers' influence on student learning varied in their attractiveness to students. This depended on teachers' approach to teaching, their "understanding of students' psychology", and their "attitudes towards, and ways to communicate with, students". He thought "the most successful teachers were those whom students adored, respected or liked. Students would like to follow these teachers' instruction".

To Mr. Hao, IBT seemed to be defined as applying a process that follows several specific steps. He stated,

> The process of inquiry is to define a train of thought, let students guess, or design, what is related to (the investigated objectives), and then (allow students to) experience a series of independent activities to obtain a physics rule or achieve a result.

He argued that "the key to IBT is to guide students to find relationships" between the observed phenomena and the questions they are investigating. If teachers fail to do so, students may not do a real inquiry. For example, Mr. Hao suggested that if a teacher used demonstration to show students several possible relationships directly (students did not propose these possible relationships first) and then asked students to find solutions, he perceived the followed students' inquiry activities as "only replicating what teachers did".

Therefore, he asserted that,

> The process of inquiry needs students to have, first, good discipline, second, good learning habits, and third, certain basic abilities to inquire.

Furthermore, he emphasised that IBT was advocating a new approach to learning, which was different from the way students were taught in their prior schooling.

> To use another approach to learning, students have to be trained from starting primary school. Human thinking cannot be switched in one step. Only if students use this approach to learning in their primary and

> junior secondary schools, could they have such a thinking habit. If students do not have such a habit of learning, such a way of thinking, in their prior schools, they would be confused using this (learning approach) in senior secondary schools, they would not make progress, and they would feel completely in the dark.

He therefore claimed that inquiry set high requirements for his students as he felt his students had very poor abilities to inquire and their abilities differed significantly, and thus it was very difficult for them to do inquiry. In addition, he implied that IBT may be not effective for the students with low abilities to learn. Mr. Hao had tried IBT in his classroom and found that his “classroom was in disorder” and his “students were lost” in inquiry. Although he suggested that he “may be not capable enough to analyse students’ situation thoroughly and thus his designs of IBT were unfit for students’ actual situation”, he mainly attributed these consequences to his students’ low abilities rather than his own improper use of inquiry.

Meanwhile, Mr. Hao was concerned about the assessment of outcomes of IBT. He pointed out that the CEE did not assess students’ abilities to inquire, and was not *able* to assess them. He felt under pressure in the current CEE as it was impossible for him to ignore students’ test scores.

Instructional decisions

Mr. Hao believed that his students needed to be provided with very specific instructions. Otherwise, his students would lose their direction in learning. He stated,

> (First), only the No.1, 2, 3, 4 (basic steps to solve problems) were told. And then, when they were skilled in the steps, (I let them) extend. If I did not set these basic steps for them, they would not know the basic things, and they would be muddle-headed in doing extension.

Regarding his instructional decisions, he indicated this was his way to teach. The instructional strategies he chose for his students were based on consideration of his students’ situation, because “the best way to teach was the one most suitable for students’ situations”.

Concerning IBT, he claimed that he would conduct it sometimes when “the content of teaching was easy to organise considering students’ situation”. In addition, he tended to treat IBT as something to demonstrate teachers’ “ability to teach”, and this teaching method was sometimes employed when outsiders came to observe his teaching.

Instructional practices

In his classroom, Mr. Hao always provided very specific instructions and required students to take notes. Mr. Hao rarely implemented IBT in his classroom. However, Mr. Hao tried IBT in his classrooms when the researcher went to observe his classroom the first time. In this lesson, Mr. Hao tended to represent a full circle of inquiry by a small student activity: students were required to observe a phenomenon, propose hypotheses, design hands-on activities, analyse data, formulate explanations, and communicate results. Students were very excited to do so, however, most of them were just playing and chatting rather than seriously thinking and discussing. The group members did not work collaboratively and in most groups there were only one or two students working. It seemed that Mr. Hao’s students did not have a good sense of inquiry. Later on in this lesson, Mr. Hao continued to use IBT in the student experiments. He guided students to formulate several problems, design experiments, collect data using digital information system (DIS), and then analyse the data. This lesson could not be finished on time. Mr. Hao felt this lesson was unsuccessful and ineffective because he found that his classroom was in disorder and his students were ‘lost’ in inquiry.

Mr. Min

Mr. Min was teaching in a private school (School Flamingo). This school was the only private school in this district, normally admitting students who could not reach the cutoff score of the public schools in the SSSEE. The students' average intellectual/academic level was supposedly lower than the general cohort of students in this district. Students' family backgrounds differed widely.

Mr. Min was young and had just graduated with a Masters Degree in Physics Education from a famous normal university[8] in China. He however had taught for four years in a key school in another province of China before he went for his full-time Masters' study.

Beliefs

Mr. Min stressed that physics was a science subject based on experiments. Therefore, he laid particular emphasis on experiments. For him, teachers' demonstrations and student practices were important in teaching and learning physics because,

> The experiment, firstly, can enhance students' understanding of the nature of physics. Secondly, it can foster students' interest in learning physics. If students' interests were enhanced, other aspects of learning could be improved naturally, including test scores and passion for science.

Because of this conception, he suggested that "secondary schools should enhance their experiments teaching" as he found "a lot of schools did not pay attention to student experiments; they mainly focused on drill training in order to improve students' test scores".

Furthermore, he suggested that through experiments "students were at least able to develop manipulative skills and abilities to collaborate with others". He felt this was very important for his current students as he found they had very low abilities in these areas. Therefore, he reported that he "always performed some demonstrations in the classroom and brought students to the laboratory to do experiments". In addition, he would design better classroom demonstrations for more student involvement although the school lacked experimental materials and apparatus.

Regarding teaching and learning, although Mr. Min had been teaching for four years, his previous teaching experience in a key school seemed not to help him much. He constantly mentioned he had no experience with such students and had to "test each step before taking it". In his opinion, his current students "were lazy and had low learning autonomy". He felt that he had to concentrate more on basic knowledge and skills and there were many things he could not do in the classroom. Therefore, "the formation of good learning habits was very essential to these students".

> Teaching in this school, I feel these students have bad learning habits. It is therefore more important to develop (good) learning habits for them (than students in other schools), as all these students are those who failed in the senior secondary school entrance examination and who are not good enough. For example, they cannot even write a Chinese character upright. They cannot make a complete expression of a physics problem when required to do so. To clearly present a physics problem, you have express it perfectly in words, graphs, and formula, but they generally only use formulas. They treat physics as mathematics.

Mr. Min hoped that his students could "develop abilities rather than improve test scores" though his teaching. He did not want his students to be "test machines". In relation to IBT, Mr. Min suggested that for him inquiry meant "students' autonomous learning". Correspondingly, he defined the teacher's role as being a guide.

[8] 'Normal university' in China means a teacher education institution

> The students are able to autonomously learn, discover problems and solve them, this is inquiry. … Let students be the centre of learning, teachers give full play to the guiding role. To let students be the centre of learning, teachers should not take the place of their students in many cases. The students should be allowed to complete learning by themselves in order to experience the process of a scientific inquiry.

Mr. Min suggested that to do so set higher requirements for his teaching, because "unexpected situations in classrooms occurred more often" which "increased the degree of difficulty of teaching". However, he argued that IBT could benefit students more than traditional teaching approaches in "improving students' autonomy, and abilities to solve problems and collaborate with others". In addition, "teachers gained experience in IBT which could benefit them as well".

Mr. Min affirmed that the elements of inquiry would be presented in his lessons when starting a new topic. However, he felt that he was struggling to do so. He admitted that he sometimes might change his plan because he found it did not work. He attributed this to his "lack of experience in conducting IBT". He also pointed out that "I sometimes had to change my ideas because we (teachers) had no choice but to be compared by test scores".

Instructional decisions

Mr. Min asserted that his teaching was still routine teaching. He decided to give his main attention to developing students' learning habits. As he stated,

> (My) teaching, currently, is mainly focused on routine instructions. I spend more time on learning habits. For example, (students are required) to preview the content before the lesson….I usually require students to preview the content before the lesson, and record their questions and something they do not understand in a special notebook. And I check them before the lesson…These questions are references to my lesson planning.

A lthough Mr. Min showed particular concern for his students' learning habits, he indicated that giving up IBT was not necessary for these students in his physics classrooms. On the contrary, he described being flexible and willing to use this teaching approach when there was content of teaching he felt suitable to conduct IBT.

> R: Do you plan to implement inquiry-based teaching in your classroom?
>
> Min: I certainly will. There is a lot of content suitable, but it is not necessary to complete the whole process of inquiry in one lesson. Pick one point and concentrate on this point. Because a lesson is 40 or 45 minutes long, it is impossible to complete the whole process. It will be the focal point of the lesson that requires students to inquire about. There will be a particular emphasis each time.
>
> R: In what type of lesson do you feel you will use IBT?
>
> Min: Depends on the specific content….If a specific content, I feel, can improve students' interests, or leaning abilities, or some aspects of (students') qualities, I will use it.

Instructional practices

Mr. Min changed his teaching plans according to his self-reflections after he had a lesson in one class and before he went to another class.

In Mr. Min's normal lesson, he used different demonstrations to attract students. Some came from the textbook, some were designed by him. He probed students' prior knowledge by asking different questions. He gave students opportunities to do hands-on activities.

In the lesson in which he conducted IBT, he grouped the students into small groups and required each student to take responsibility. Before starting the experiments, he guided the students to design their experiments and develop the method and process to collect and analyse data. During students' experiments, he walked around to check all groups and sometimes gave them very specific instructions. However, many of his students seemed not to be concerned about the inquiry activities, and many of them seemed to feel it was very difficult, or confusing, to follow his instructions.

Summary and Discussion

Results can be summarised in relation to the research questions of the study as follows:

1. What beliefs do Chinese physics teachers hold about
    a. the nature of science?
    b. teaching and learning science?

It seemed that teachers were very aware of their teaching contexts. None of these teachers mentioned any assessment criteria besides test scores for assessing students' learning outcomes. They cared about their students' scores in exams, particularly when their students' scores were linked to administrators' perceptions of their ability to teach. Teachers tended to perceive risks in implementing IBT when it was not possible to ignore society's desire for students to achieve high examination scores. This indicated that the assessment system needed to be reformed in order to keep up with the changes in teachers' instructional practices.

    c. the nature of inquiry-based teaching (IBT)?

The five teachers offered different descriptions of IBT. This was related to their individual experience of knowing, conducting, and forming an understanding of IBT. It seemed that they had some misconceptions about IBT during this process. From another point of view, this indicated that these teachers may have lacked appropriate professional support and professional development during the reform process. It seemed teachers were not provided with enough scaffolding or support systems to understand the essential features of inquiry and its application. The lack of professional support may have caused teachers to be unable to confidently apply IBT in their classrooms, to use IBT improperly, or to consider IBT as unimportant.

2. How do Chinese teachers
    a. perceive the changes in the curriculum?
    b. interpret inquiry-based teaching (IBT)?
    c. implement IBT in their teaching?

The five teachers made different compromises to accommodate their ideas of IBT into their day to day teaching. This was reflected in their instructional decisions.

Mr. Lu did not make a change and continued to implement a lecture method of teaching in his classroom. Ms. Ding decided that she could implement IBT in one section of class, and created a kind of activity called "speculative inquiry" without involving students in hands-on activities. Mr. Zhao employed a method to offer students vicarious experience of inquiry activities but seldom gave them direct experience of inquiry. Mr. Hao implemented IBT when outsiders came to observe his classrooms to demonstrate that he was able to do so. And Mr. Min decided to be more flexible when there was content he felt was suitable to conduct IBT.

It seemed that teachers created their own ways to conduct IBT to be consistent with their belief systems. These, however, may or may not be considered to be canonical and appropriate approaches to implementing IBT, and may not fit the curriculum planners' intentions in mandating inquiry-based teaching. Therefore there needs to be an effective support system to help teachers justify their instructional practices and form unique approaches to IBT in their teaching contexts – and to come to understand whether these approaches in fact meet the goals and intentions of the curricular reforms.

3. What are the associations between teachers' beliefs and their instructional practices regarding IBT?

Physics teachers' instructional decisions regarding IBT were strongly associated with teachers' beliefs. However, teachers' beliefs and practices interacted in complex ways. Teachers' beliefs were linked to their unique situations of teaching and individual experience, and exerted complex influences on their instructional decisions.

Teachers' practices may modify or reinforce teachers' beliefs. For example, Mr. Zhao changed his opinions on drill training when he found that his students' test scores were always lower than other teachers' students who had a large amount of drill training.

Teacher beliefs were shaped by the cultural practices of society, which may or may not be consistent with their own beliefs about teaching and learning. Consequently, some teachers demonstrated some conflicting beliefs and inconsistencies between their beliefs and instructional decisions.

Conclusion

This study reveals that the five Chinese senior secondary physics teachers differed significantly in their beliefs in relation to the nature of science, teaching science and the nature and value of inquiry-based pedagogies. These beliefs exerted complex influences on teachers' instructional decisions regarding inquiry-based teaching (IBT). Although teachers followed the same curriculum standards and the content of teaching was similar, the instructional strategies they chose for their students in relation to IBT were varied.
It is not difficult, however, to identify a prominent theme among these beliefs and their influences: teachers' perceptions and beliefs about 'effective teaching' seemed to dominate their instructional decisions with respect to IBT. In addition, views about students' abilities to learn, learning habits, and interest in learning physics seemed to occupy a significant position when these teachers considered what constituted effective teaching. What teachers chose was what they believed was the most effective strategy to achieve their teaching objectives. Their beliefs helped them to legitimise their own instructional decisions.

Meanwhile, teachers' beliefs were contextualized by and related to their professional experiences. Therefore, the five teachers' beliefs and their influences on teachers' instructional decisions regarding IBT should be understood in the context of their teaching situations and China's curricular reforms. They were teaching a reformed, inquiry-based curriculum while working within an assessment system with different imperatives and objectives, they were facing different groups of students, pressed for time, and under high pressure to prepare students for the CEE.

Given that inquiry-based approaches are being adopted in school systems throughout the world (Abd-El-Khalick et al., 2004), these challenges are likely to be shared by teachers in many countries. This study suggests the importance of developing effective assessment systems to relate student performance to teachers' inquiry-based instruction, as the curriculum reform had already mandated "a new assessment system characterised by multiple assessment indicators and multiple ways of assessment, which takes both outcome and process into account" (Poisson, 2001, p. 17), however the curricular changes have been implemented in advance of the development of revised assessment, and in a context where the assessment regime is not complementary to the mandated pedagogical approaches. In addition, the five teachers' stories also suggest that appropriate professional development programs and multiple sources to scaffold teachers' effort at implementing IBT are essential, and that changing teachers' professional practices requires addressing core beliefs about the nature of science and science teaching.

Further research of this kind – close-grained qualitative inquiry that links teachers' beliefs and assumptions with their classroom practices – will contribute to better understandings the forms of support required by teachers and within education systems if inquiry-based curricular reforms are to be successful.

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