Chapter 6
Learners' Epistemic Beliefs and Their Relations with Science Learning—Exploring the Cultural Differences

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Abstract This chapter discusses the cultural differences in learners' epistemic beliefs (EBs) and the relations with science learning by cross comparing empirical studies from different countries in the recent 10 years. The reviewed papers were collected from the Social Science Citation Index (SSCI) database on the research platform, *Web of Knowledge,* from 2004 to 2013. A total of 106 papers were included in the review. Comparisons of the research purposes, questions, and findings were made across different countries to reveal possible cultural differences. The analysis shows that among the eight issues abstracted from the 106 papers, the four which received the most attention were the status of students' EBs (or conceptions of learning, COL), the role or effects of EBs (or COL) in science learning, the effects of instructional intervention on changes in EBs, and the relations between EBs and study approaches. Since most studies were conducted in Taiwan, Turkey, and the USA, the cultural comparisons were made mainly across these three countries. It was found that learners from Taiwan and the USA, which were identified as having lower context cultures, seemed to have developed more sophisticated beliefs about knowledge, but they tended to believe more in the innate ability of learning. On the contrary, learners from Turkey as well as China, which were recognized as having high-context cultures, tended to believe more in authority knowledge while relying more on the value of effort. While not much difference in the relations between learners' EBs and science learning could be found across Taiwan, Turkey, and the USA, it was much easier for the EBs of learners with low-context cultures to be affected by instructional interventions.

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6.1 Introduction

In the research of psychology, personal epistemology has been identified as the highest level cognition mediating human activities, including thinking and problem solving. Many psychologists argue that personal epistemology undergoes a developmental process which is highly related to an individual's educational experiences. A considerable number of educational studies exploring learners' personal epistemic beliefs (EBs) and their roles in learning have been accumulating over the recent 10 years. Although, in general, these studies agree that personal EBs play a significant role in the process of learning, how these beliefs affect students' learning behaviors might not be universally the same. It is certain that there should be social or cultural influences on the development and the actions of EBs. However, such an issue has not been extensively explored.

In this chapter, an attempt is made to discuss the cultural differences in EBs and their relations to science learning. To this end, we first review educational studies involving investigations of learners' personal EBs and the effects of these beliefs on science learning in the past 10 years (from 2004 to 2013). Then, by cross comparing the research themes and findings of each study conducted in different countries, we hope to reveal cultural differences in the role of EBs in science learning.

6.1.1 EBs in the Context of Science Learning

The study of personal epistemology originating from Perry's studies of intellectual development (Perry 1998) concerns an individual's beliefs about the nature of knowledge and knowing. Psychological studies have shown that personal epistemology as the highest level of cognition mediates human cognitive behaviors (e.g., Hofer and Pintrich 1997; Hofer and Pintrich 2002; Perry 1998). In later years, Schommer (1990; Schommer-Aikins 2004) used the term personal epistemological beliefs to specify learners' beliefs about the nature of knowledge and learning. Many subsequent studies, especially in the field of education, have explored learners' personal epistemic theories in accordance with such a definition. Although some scholars argue that aspects of personal epistemology include only the nature of knowledge and knowing (Sandoval 2009), the conceptual overlap between the nature of knowing and learning is evident. As a matter of fact, Perry's structure of personal epistemology was generalized from students' educational experiences in their college years (Perry 1998). Accordingly, personal beliefs or theories about learning reflect to a certain extent one's beliefs about the nature of knowing.

In the context of education, it has been recognized that teachers' as well as students' beliefs about knowledge taught in school, and their ideas about teaching and learning have been recognized as a crucial determinant affecting classroom practice. As far as science learning is concerned, considerable studies have suggested that students' personal epistemological beliefs mediate concept learning, the uses of learning strategies, and the practices of argument skills (see a recent review by Yang and Tsai 2012). Also, as will be shown in this review work, in the context of science

education, beliefs or conceptions about the nature of teaching and learning are found to be associated with teachers' educational decisions, students' school performance, and the study approaches. Accordingly, to understand students' science learning behaviors, an in-depth investigation on learners' EBs will be informative.

To avoid the confusion of theoretical definition for personal epistemology, researchers in the fields of psychology and education nowadays use the term personal "epistemic beliefs" instead to indicate the wider range of beliefs about knowledge, knowing, teaching, and learning. In this chapter, we focus on analyzing learners' personal EBs in science and their relations to science learning.

6.1.2 Cultural Differences and Science Learning

The effects of culture have been identified in various areas of research, such as business management, anthropology, psychology, education, and online commercial advertising (e.g., Chan 1999; Enz 1986; Hall 1976; Korac-Kakabadse et al. 2001; Marcus and Gould 2000; Triandis 1989; Würtz 2006). Basically, these studies pointed out that cultural rituals and values are reflected in communication styles and social behaviors. As far as learning is concerned, cultural differences have been identified in learning styles, school performance, study approaches and so forth (e.g., Ogbu 1992; Irvine and York 1995). Recent research about web-based learning reports that cultural differences are apparent in perceptions of online discussions, expectations about instructors and students, and styles of interaction and information approaches (Cifuentes and Shih 2001; Hannon and D'Netto 2007; Morse 2003).

In the literature, studies about cultural differences in science education mainly discuss the differences between students and science teachers in the same classroom (e.g., Erickson 1986; Cobern and Aikenhead 1998; Hammond and Brandt 2004). Few studies have examined the cultural differences across different nations. A recent "Organization For Economic Co-Operation And Development" (OECD) report about the PISA 2006 test shows that although numerous Asian students in certain countries demonstrated high science and mathematics abilities, their interest and motivation in learning science as well as their tendencies to pursue future careers in science were not as high as their performance would suggest (OECD 2007). The situation differs from prior educational studies which found that the higher students' interest and motivation, the better their school performance will be (Pintrich and Schunk 2002). It is apparent that there are cultural factors giving rise to such an outcome, which are worthy of further exploration.

6.2 Objective of the Study

The main purpose of this study is to examine whether differences from cultural perspectives can be found in the empirical studies about EBs and science learning in the past 10 years. By reviewing relevant papers published in SSCI journals from 2004 to 2013, we hope to gain insights into the effects of cultural entities on

learners' EBs and how beliefs developed under different cultures could lead to different outcomes of science learning.

6.3 Method

6.3.1 Paper Selection

The papers selected for review came from the Social Science Citation Index (SSCI) database included in the research platform, Web of Knowledge, developed by Thomas Reuters (http://apps.webofknowledge.com). Topic keywords such as "personal epistemology," "epistemological beliefs," and "epistemic beliefs" were combined with "science learning" using the Boolean operator, AND, to find papers of interest. Each combination was then put together using the history tracking tool provided by the search platform to locate all relevant papers from 2004 to 2013. A total of 168 papers were abstracted from the selection. Subsequently, an inspection of the abstract of each paper was carried out to confirm that each paper had objectives related to studies about learners' EBs (including the terms of EBs, personal epistemology, and epistemological beliefs) and science learning. Additionally, book chapters, review papers, and those papers written in languages other than English were excluded from the review. A final total of 106 papers were identified for the review.

6.3.2 Paper Analysis

To present the cultural differences, we focus majorly on analyzing the participants, the study purposes, research questions, and the study findings of each collected paper. Descriptive analysis and cross-country comparisons are then conducted to capture the cultural differences.

6.4 Result

1. *Distribution of countries*

Among the 106 studies, about 35% were conducted in Taiwan, 25% in the USA, and 11% in Turkey. The remaining 29% were distributed among 18 countries. Figure 6.1 shows the paper distribution across 21 countries.

2. *Study issues*

In all, eight issues were abstracted from the 106 papers as indicated in Fig. 6.2. By analyzing the study purposes and research questions, it was found that the majority of the collected papers (77%) focused on issues concerning the status of students'

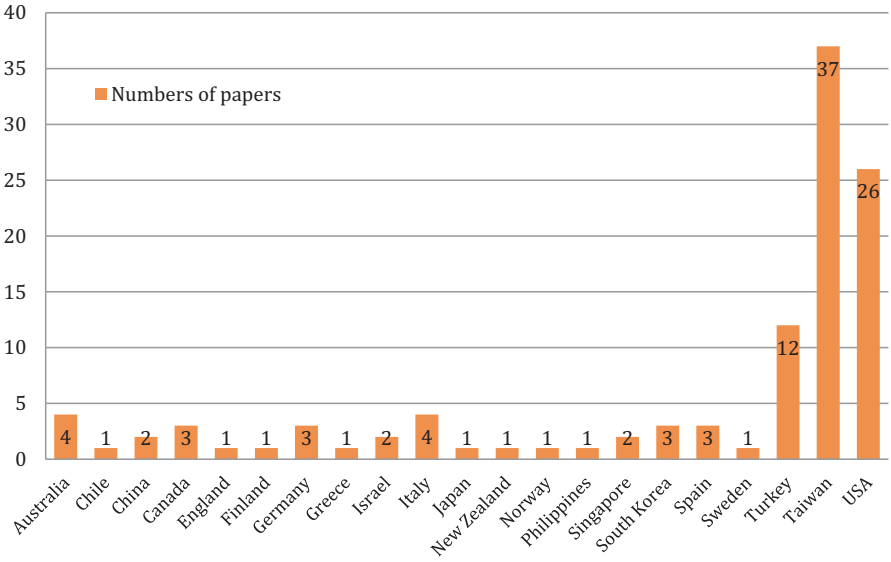

Fig. 6.1 Numbers of papers by different countries from 2004 to 2013

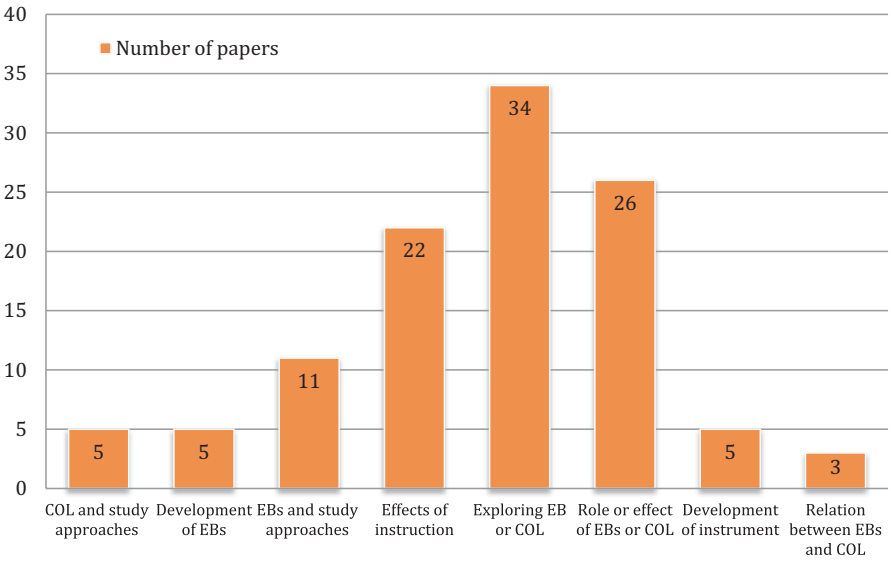

Fig. 6.2 Distribution of study issues (Note: *EBs* epistemic beliefs; *COL* conceptions of learning)

EBs or COL, the roles or effects of EBs or COL in science learning, the effects of instructional intervention on the changes in EBs, and the relation between EBs and study approaches. It should be noted that some studies involve the discussion of two issues.

3. *Subjects*

Among the 106 papers, 37 dealt with university students, 34 involved high school students, 15 studied student teachers, and 10 explored elementary learners. Meanwhile, there are ten studies investigating in-service teachers' EBs. The rest involved adult subjects or faculty members. Overall, adults were the main subjects under investigation.

4. *Cultural difference*

Figure 6.2 shows that the majority of the collected papers (90 papers, about 85%) focus on issues concerning the status of students' EBs and/or COL, the effects of instructional intervention on changes in EBs, the roles or effects of EBs and/or COL in science learning, and the relations between EBs and study approaches. Accordingly, the main analyses of cultural differences involve these issues. Moreover, due to the fact that most of these papers are distributed across three countries, namely Taiwan, the USA, and Turkey, the comparisons mostly concern the differences across these three countries.

(1) Status of learners' EBs

Among the 34 papers related to the status of students' EBs about knowledge in science and learning, 9 are from Taiwan, 6 were conducted in Turkey, and 5 in the USA. The studies from Taiwan showed that university students and in-service teachers held from moderate to advanced EBs in scientific knowledge (e.g., Yang et al. 2008; Liu and Liu 2011; Lee et al. 2012), but their beliefs about learning were rather simple, that is, they seemed to believe more in innate and fixed ability (e.g., Yang et al. 2008; Lee et al. 2012). A large-scale survey showed that high school students expressed different EBs about different science subject matters (Tsai 2006). A similar result was found for university students (Lee and Tsai 2012). Gender difference was reported in some investigations where male students showed more advanced EBs in knowledge (e.g., Tsai 2006, 2008).

In Turkey, the study findings are less than conclusive. In one study, university students were found to have moderate EBs in knowledge and learning (Er 2013), while another reported constructivist views about learning (Kabapinar 2012). Gender and background discipline were found to contribute to the variety in EBs (Er 2013; Ertekin et al. 2009). Meanwhile, domain-specific EBs in scientific knowledge were found among high school students (Ogan-Bekiroglu and Sengul-Tugut 2011).

Studies from the USA reported that students' beliefs varied across different genders, grade levels, and ethnic groups, and how students think about scientific knowledge depended on the tasks, learning environments, and contextual cues (Watkins and Elby 2013; Chen 2012). A large-scale study (Chen 2012) showed that high-school students in general held sophisticated epistemic views on scientific knowledge, but their beliefs in learning were simple. In other words, they believed more in innate ability. Wheeler and Montgomery (2009) reported in their study that while most college students displayed largely simple to moderate views on math learning, some students were moving toward the sophisticated form.

The study results from Taiwan, Turkey, and the USA as introduced above suggest that learners in Taiwan and the USA might have developed more sophisticated

beliefs in scientific knowledge compared to the learners in Turkey. However, in terms of beliefs in learning, students in Taiwan and the USA tend to believe that learning depends on fixed and innate ability. On the other hand, Turkish students seem to be more diverse in terms of their beliefs in learning. These comparisons imply that students from Taiwan and the USA are similar in their EBs in knowledge and learning, which differ evidently from those held by Turkish students. Studies of the three countries indicate that displays of EBs are largely affected by educational experiences, problem contexts, and knowledge domains.

While the above comparisons are made indirectly, there are three papers providing direct cultural comparisons of students' EBs (Lin et al. 2013; Lee et al. 2012; Chai et al. 2012). These three studies compared students from Taiwan, Singapore, and China. The results showed that students in Taiwan possessed more advanced beliefs in knowledge than did Chinese students, but their beliefs in innate and fixed ability were stronger. The authors of these studies argued that although these three countries share the same Chinese culture, the different educational philosophies might have asserted an influence on the development of their EBs.

(2) The role or effects of EBs in science learning

Four studies in Taiwan discuss the role of EBs in the process of science learning. It was found that sophisticated EBs promote the development of inquiry skills (Wu 2011), guide the use of evaluation standards for online information (Lin and Tsai 2008), and affect views on the nature of science (Yang 2005). One study showed that teachers' EBs drove their pedagogical attention (Tsai 2007). The only study from Turkey demonstrated that advanced EBs were associated with higher levels of learning and performance goals, while six studies from the USA showed that students' EBs were associated with their academic achievement (Beghetto 2012; Nussbaum et al. 2008), academic motivations (Ricco et al. 2010) and learning as well as problem-solving behaviors (Gupta and Elby 2011; Lising and Elby 2005; Ravindran et al. 2005). In addition, three studies from the USA indicated that teachers' instructional goals and decisions were affected by their EBs (Knobloch 2008; Benett and Park 2011; Kang 2008), which would then give rise to different learning environments.

In sum, the role or effects of EBs in science learning seem to be universally the same across different countries. Evidently, the more sophisticated form of EBs, the better development in academic-related cognitive processes and higher motivations for learning. Although most of the studies listed above provide findings indicating correlational rather than causal relationships, since the development of EBs take time and they are at the highest level of cognition, it is reasonable to infer that EBs are the major underlying determinants for students' (as well as teachers') performance.

(3) The effects of instructional interventions

Among the 22 papers that discuss the effects of instructional intervention, only one study was conducted in Taiwan. This study (She 2004) describes an instructional approach that challenges high school students' EBs. The results showed that such an approach fostered radical conceptual change. On the other hand, four studies from Turkey explore whether inquiry or problem-based instruction are able to

change students' epistemic status; their findings are inconclusive. For university students, instructional interventions seemed to provide no effect in terms of belief change (Coban 2013; Smith 2010), but for elementary and high school subjects, their EBs were much more easily influenced (Cam and Geban 2011; Kizilgunes et al. 2009). All ten studies from the USA showed that students' EBs were changeable, regardless of their age or educational level. Some important features of the effective curriculum include the presence of inquiry or problem solving activities (e.g., Lindsey et al. 2012; Sandi-Urena et al. 2011), the inclusion of dialogic or argumentative interactions (e.g., Walker et al. 2013; Reznitskaya and Gregory 2013), and the involvement of reasoning or critical thinking processes during learning (e.g., Gottesman and Hoskins 2013; Gill et al. 2004).

In sum, while adult students in Turkey tended to maintain their EBs after inquiry-based instructional interventions, the USA students, regardless of their age or educational level, seemed to be more flexible in terms of adjusting their EBs. Although the disparity between the two countries might come from different instructional approaches, the possibility of cultural difference could not be ruled out.

(4) Relations between EBs and study approaches

As shown in Fig. 6.2, 11 papers discuss the relationship between EBs and study approaches. Rather than originating from just a few countries, these papers are distributed across nine countries, and have a similar finding, namely that sophisticated EBs are associated more with deep study approaches, while simple or naive beliefs are related to surface approaches (e.g., Nieminen et al. 2004; Watters and Watters 2007).

(5) Other issues

Other than the abovementioned study issues, five papers conducted in five different countries discussed the development of EBs. A general progressive trend related to age and educational experience was shown (e.g., Thomas 2008; Rivero et al. 2011). Another five studies aimed to develop valid instruments for assessing EBs (e.g., Suzuki 2005; Colbeck 2007). Finally, the issues related to learners' COL and their relations with EBs and other learning behaviors were only examined by researchers in Taiwan (e.g., Tsai 2004; Lee et al. 2008). These papers show consistent results, but no cultural difference can be drawn.

6.5 Discussion

Culture is a complex set of basic assumptions, values, life orientations, politics, social habits, beliefs, customs, laws and more, which are shared by a particular group of people (Spencer-Oatey 2008). For anthropologists, culture is itself a series of situational models for behavior and thought (Hall 1976). Hall proposed that culture could be referred to as a continuum of contexts from high to low. In a high-context culture, many things are left unsaid, letting the culture explain. Word choice becomes very important because a few words can communicate a complex

message. On the other hand, in a low-context culture, the communicator needs to be much more explicit, and the value of a single word is less important. For example, Chinese writers often use some indirect stories or expressions to reflect a certain problem or issue while English writers usually pinpoint the problem or issue to be discussed explicitly in the beginning of their articles.

As mentioned before, issues related to EBs and science learning were examined mostly by researchers from Taiwan, Turkey, and the USA in the past 10 years. Taking into consideration the cultural entities, these three countries just represent different cultural contexts. Based on Hall's definition, the USA is a representative of a low-context culture while Turkey, with its rich ancient history and strong religious influences, is a country with a high-context culture. Meanwhile, since Taiwan, although with its deep Chinese cultural roots, has been westernized and developed into a democratic society, its cultural tendencies could fall somewhere between the high and low contexts. These different cultural contexts might help to explain more of the differences in learners' EBs.

It has been shown that students from Taiwan and the USA with relatively lower cultural contexts seem to have more sophisticated beliefs in scientific knowledge, but they tend to believe more in fixed and innate ability in learning. On the contrary, students from Turkey and China, which are identified as having high-context cultures, are more likely to believe that scientific knowledge is certain and experts warrant the validity of knowledge, but they believe less in fixed ability. As far as the role or the effects of EBs in learning are concerned, no distinct cultural differences can be drawn from the collected studies. Regarding the change in EBs, it has been found that the USA learners compared to those from Turkey have more flexible EBs which seem to be much easier to influence by instruction incorporating inquiry activities with dialogic or argument events.

If, as proposed by Hall, we see culture as a continuum spectrum ranging from low to high contexts, based on the analyses discussed in this chapter, it is concluded that culture plays a role in securing learners' beliefs in knowledge and learning. High-context cultures with a strong emphasis on collectivism might promote conformity that results in a simpler form of beliefs in scientific knowledge while cherishing more the importance of efforts. Low-context cultures on the other hand, focusing more on individualism, value personal development, which as a result promotes sophisticated thoughts on the nature of knowledge but gives higher weight to innate ability. However, it is seemingly the low-context cultures that allow more room for self-improvement and adjustment in EBs. As mentioned in the introduction section, studies in various fields have found that cultural rituals and values are reflected in communication styles and social behaviors. In educational research, cultural differences have also been identified in learning styles, school performance, study approaches, and perceptions of elements of learning environments. Given that EBs mediate learning, by considering the cultural difference in EBs, educators may understand more of learners' learning behaviors and performance in different cultural contexts.

6.6 Limitation of the Study

In this chapter, we made an attempt to examine the cultural differences in the status and development of the EBs in science by cross analyzing relevant studies conducted in different countries. The analysis made in the study supports that culture plays a role in shaping learners' EBs which in turn mediate the process of school science learning. A genuine social-cultural comparison study requires the direct and empirical investigation and the information about the contexts of classrooms, the social–cultural–historical backgrounds of the participants and so forth is needed to make thorough discussions. Given that the study reported in the chapter is basically a work of literature review, conclusions drawn from the review analysis may suffer from being rather broad and superficial. For example, the USA is a nation consisted of large heterogeneous societies. Our study findings might reflect only a small portion of the reality.

As a matter of fact, the chapter is written in the hope to raise the attention from educators and educational researchers in Taiwan on the cultural differences regarding learners' epistemic development. Very often when educators in Taiwan tried to launch a new instructional reform, the new ways of teaching and learning encountered strong resistance or ineffective result that were not found in other countries which had successful reform practices. We believe that the major problem lies in the lack of understanding of the cultural differences. It was likely that students in Taiwan had not developed proper EBs that could guide their reasoning and learning in a new learning environment. We thus advocate that before starting a new educational reform, a careful investigation on the cultural differences in learners' epistemic theories will help local educators to develop the adaptive curriculum that gradually promote the desired learning goals and performances.

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