Teacher beliefs and practice in science education

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Contents

Abstract

Teacher beliefs and practice have been widely debated by educators in order to understand the nature of the relationship between these concepts. Despite the ongoing discussion, there is still no clear definition of belief and it has been used interchangeably with knowledge. Therefore, the first purpose of the study was to clarify the definitions and nature of beliefs and knowledge in order to understand the relationship between teacher beliefs and practice.

Moreover, many scholars believe that teachers have a crucial role in implementing change in schools. Therefore, many research studies have been conducted in science education on a variety of issues. However, the findings of the research indicate that the relationship between teacher beliefs and practice is controversial and has a complex nature. The second purpose of this paper is to critically analyze research studies in terms of their weakness and strengths with some recommendations for further research.

Keywords: Teacher beliefs and practice, Science education

Introduction

Beliefs have been receiving a great deal of attention from educational researchers and widely discussed in the literature (Fang, 1996; Kagan, 1992; Mansour, 2009; Nespor, 1987; Pajares, 1992). Although there have been many studies related to beliefs, educational researchers still discuss the definitions and nature of beliefs. Therefore, there is a need to clarify the terms and definition of a belief in order to better understand the relationship between teacher beliefs and practice. The first part of this paper discusses the definitions and nature of beliefs as found in literature and makes distinctions between beliefs and knowledge.

Studies of beliefs are mostly related to classroom practice and the relationship between teacher beliefs and practice has widely been discussed in regard to a broad variety of issues in science education including: (a) constructivism (Beck, Czerniak, & Lumpe, 2000; Haney, Lumpe, & Czerniak, 2003; Haney & McArthur, 2002); (b) curriculum (Cronin-Jones, 1991); (c) goals of science education (Mcintosh & Zeidler, 1988); (d) inquiry (Luft, 2001; Wallace & Kang, 2004); (e) nature of science (Gess-Newsome & Lederman, 1995; Hashweh, 1996; Lederman, 1999; Lederman & Zeidler, 1987); (f) reform strands (Haney, Czerniak, & Lumpe, 1996; Roehrig & Kruse, 2005); (g) science, technology and society, (Lumpe, Haney, & Czerniak, 1998); (h) teaching and learning (Hancock & Gallard, 2004; Haney, Lumpe, Czerniak, & Egan, 2002; Laplante, 1997; Levitt, 2002; Lumpe, Haney, & Czerniak, 2000; Mellado, 1998; Porlan & del Pozo, 2004); and (i) thematic units (Czerniak, Lumpe, & Haney, 1999). These studies indicate that the relationship between teacher beliefs and practice is controversial. Some studies (Cronin-Jones; Haney & McArthur; Haney et al., 1996, 2002; Hashweh; Levitt) found that teacher beliefs are consistent with classroom practice, while others found that teacher beliefs do not necessarily influence classroom practice (Hancock & Gallard; Lederman; Lederman & Zeidler; Mellado). These studies also indicate that teacher beliefs should be considered within context because of the context-dependent nature. Therefore, the second part of the paper critically analyzes research studies regarding the relationship between teacher beliefs and practice with other influential factors discussed in the science education literature.

Part 1: Debates on Definitions and Nature of Beliefs and Knowledge

Belief, as a term, has been defined in a variety of different ways in the literature and used interchangeably with a variety of other terms including attitudes, values, judgments, opinions, ideology, perceptions, conceptions, conceptual systems, dispositions, implicit theories, explicit theories, internal mental processes, action strategies, rules of practice and perspectives (Pajares, 1992). However, according to Pajares, the confusion focuses on the distinction between beliefs and knowledge. Therefore, it is necessary to clarify the differences between beliefs and knowledge.

Abelson (1979) defined beliefs in terms of people manipulating knowledge for a particular purpose or under a necessary circumstance. According to Brown and Cooney (1982), beliefs are dispositions to action and major determinants of behavior. Rokeach (1972) defined beliefs as “any simple proposition, conscious or unconscious, inferred from what a person says or does, capable of being preceded by the phrase ‘I believe that’” (p. 113). Rokeach discussed

three kinds of beliefs: descriptive or existential beliefs, evaluative beliefs and prescriptive or exhortatory beliefs. In descriptive beliefs, the object of belief is described as true or false, correct or incorrect (e.g., I believe that the sun rises in the east). In evaluative beliefs, beliefs can be stated as good or bad (e.g., I believe this ice cream is good). In prescriptive or exhortatory beliefs, a certain action or a situation is advocated as desirable or undesirable (e.g., I believe it is desirable that children should obey their parents).

Rokeach (1972) suggested that all beliefs have three components: a cognitive component, an affective component and a behavioral component. A cognitive component represents a person's knowledge about what is true or false, desirable or undesirable. An affective component of the belief is capable of arousing affect of varying intensity centering on the object of the belief, taking a positive or negative position in an argument. A behavioral component of the belief leads to action when it is activated. According to Rokeach, the nature of belief is somewhat similar to the structure of an atom in terms of the ways in which beliefs are organized. Rokeach claims that some of the beliefs (core beliefs) are more central, more connected to others (peripheral), and more resistant to change.

Moreover, Ackermann (1972) examined beliefs in four different categories as behavioral beliefs, unconscious beliefs, conscious beliefs, and rational beliefs. Behavioral beliefs are not distinguished simply because of fixed behavioral patterns that anyone holding a certain belief will exhibit. Rather unconscious beliefs long-standing beliefs that can influence behavior over a long period of time, but resist recognition by the agent. Unlike behavioral beliefs, unconscious beliefs cannot be interpreted from behaviors. Behavioral beliefs, by contrast, will be thought of as non-conscious rather than unconscious. Behavioral beliefs are important in human action where the agent encounters no difficulty, so that his beliefs do not require scrutiny at the consciousness level. Conscious beliefs are any beliefs a person has explicitly formulated and is aware of. Rational beliefs are defined as a philosophical idealization of actual belief structures.

Based upon a literature review of beliefs, Pajares (1992) defined belief as an "individual's judgment of the truth or falsity of a proposition, a judgment that can only be inferred from a collective understanding of what human beings say, intend, and do" (p. 316). Anthropologists, social psychologists, and philosophers have agreed upon a commonly accepted definition of beliefs; "beliefs are thought of as psychologically held understandings, premises, or propositions about the world that are felt to be true" (Richardson, 1996, p.103). In educational settings, Haney et al. (2003) defined beliefs as "one's convictions, philosophy, tenets, or opinions about teaching and learning" (p. 367).

Knowledge is another concept widely discussed in the literature. The definition of knowledge as a term can be traced back to the time of Socrates. Plato suggested that knowledge has three components: beliefs, truth, and justification (Woolfolk-Hoy & Murphy, 2001). In the traditional philosophical literature, knowledge depends on a "truth condition" that is being agreed upon in a community of people (Richardson, 1996). Based upon this definition, knowledge is a belief that meets two conditions: (a) the truth of what is believed and (b) the justification someone has for believing it (Woolfolk-Hoy & Murphy). Alexander, Schallert, and Hare stated that beliefs are a category of knowledge and define knowledge as "encompasses all that a person knows or believes to be true, whether or not it is verified as true in some sort of objective or external way" (as cited in Woolfolk-Hoy & Murphy, p. 146).

A number of scholars have made the distinction between knowledge and beliefs. As Pajares (1992) stated, the problem is associated with the difficulty of finding the border where knowledge ends and beliefs begin. Table 1 summarizes the differences between beliefs and knowledge as discussed in the literature.

Table 1: *The differences between beliefs and knowledge based on the literature*

Beliefs	**Knowledge**
Refer to suppositions, commitments, and ideologies	Refers to factual propositions and the understandings that inform skillful action
Do not require a truth condition	Must satisfy "truth condition"
Based on evaluation judgment	Based on objective fact
Cannot be evaluated	Can be evaluated or judged
Episodically-stored material influenced by personal experiences or cultural and institutional sources	Stored in semantic networks
Static	Often changes

According to Calderhead (1996), beliefs generally refer to "suppositions, commitments, and ideologies while knowledge refers to factual propositions and the understandings that inform skillful action" (p. 715). Richardson (1996) distinguished knowledge from beliefs based on the notion of "truth condition." In her definition, knowledge must satisfy the "truth condition" or have some evidence but beliefs do not require a "truth condition." Ernest (1989) proposed a distinction between knowledge and beliefs by identifying a case in which two teachers may have similar knowledge, but one can teach mathematics with a problem-solving orientation, while the other has a more didactic approach because of different beliefs they hold.

Nespor (1987) suggested that four features of beliefs: (1) existential presumption, (2) alternativity, (3) affective and evaluative loading and (4) episodic structure can be used to distinguish knowledge from beliefs. First, Pajares (1992) defined existential presumptions as "the incontrovertible, personal truths everyone holds" (p. 309). They are deeply personal and formed by chance, an experience, or an event. For example, a teacher may have beliefs about student "ability," "maturity," or "laziness" which are labels for entities about the students, rather than descriptive terms. Second, beliefs sometimes refer to "alternative worlds" or "alternative realities" which are different from reality (Nespor; Pajares). Third, belief systems depend on affective and evaluative components more than knowledge systems. Nespor suggested that feelings, moods, and subjective evaluation based on personal preferences may significantly influence one's belief system. Unlike knowledge systems, belief systems do not require general consensus regarding the validity and acceptability of beliefs. Individual beliefs do not even require internal consistency in the belief system. Finally, Nespor differentiated these two terms based on episodic structure. A knowledge system is stored in semantic networks whereas belief systems consist of episodically-stored material influenced by personal experiences or cultural and institutional sources. In summary, Pajares synthesized the findings of research on beliefs in the literature as follows:

1. Beliefs are formed early and tend to be self-perpetuated, tend to be persistent against the contradiction caused by time, experience, reason and schooling.
2. Epistemological beliefs play a key role in knowledge interpretation and cognitive monitoring.
3. Belief substructures, such as educational beliefs, must be understood in terms of their connections not only to each other but also to other, perhaps more central, beliefs in the system.
4. By their nature and origin, some beliefs are more incontrovertible than others.
5. The earlier a belief is incorporated into the belief structure, the more difficult it is to change.
6. Belief change during adulthood is a relatively rare phenomenon.
7. People's beliefs strongly affect their behavior.
8. Beliefs cannot be directly observed or measured but must be inferred from what people say, intend, and do.
9. Beliefs about teaching are well established by the time a student attends college.

(pp. 324-326)

Part 2: Research on Teacher Beliefs and Classroom Practice

Many scholars believe that the implementation of any reform movement heavily depends on teachers (Bybee, 1993; Haney, Czerniak, & Lumpe, 1996; Levitt, 2002; Nespor, 1987; Pajares, 1992; Tobin, Tippins, & Gallard, 1994). As Prawat (1992) indicates, teachers are expected to play a crucial role in changing schools and classrooms. Paradoxically, however, they are also viewed as major obstacles to change due to their traditional beliefs. According to Bandura (1986), an individual's decisions throughout his/her life is strongly influenced by his/her beliefs. Similarly, Pajares asserts that beliefs are, "best indicators of the decisions that individuals make throughout their lives" (p. 307). Teacher beliefs play a major role in teachers' decision making about curriculum and instructional tasks (Nespor; Pajares). In summary, educational researchers have advocated the need for closer examination and direct study of the relationship between teacher beliefs and educational practices (Pajares; Pomeroy, 1993). Therefore, the relationship between teacher beliefs and practice is well documented in science education literature.

A number of studies investigating the relationship between teacher beliefs and practice have found that teacher beliefs are consistent with classroom practice. Hashweh (1996) conducted a study with 35 Palestinian science teachers in order to identify the relationship between their epistemological beliefs and classroom practices. Data obtained through the use of a three-part questionnaire consisted of critical incidents, direct questions about teacher strategies for conceptual change, and ratings of the use and importance of specific teaching strategies. The author characterized teachers as learning constructivists, learning empiricists, knowledge constructivists and/or knowledge empiricists. He found that differences in epistemological beliefs influenced classroom teaching. According to the findings of his study, teachers holding learning constructivist and knowledge constructivist beliefs are more likely to detect student alternative conceptions, have a richer repertoire of teaching strategies, use potentially more effective teaching strategies for inducing student conceptual change and report more frequent use of effective teaching strategies compared with teachers having empiricist beliefs. Although Hashweh investigated the relationship between teacher beliefs and practice, he

collected self-reported data from teachers about their classroom practice without observation. This should be considered as one of the biggest weakness of this study.

Haney and McArthur (2002) constructed case studies for four prospective science teachers in order to identify teachers' constructivist beliefs and classroom practices. Participants were purposively selected as a result of their scores on the Classroom Learning Environment Survey ([CLES] Taylor, et al., 1994). The CLES instrument has five subcategories that were viewed as critical to the formation of a constructivist classroom environment: (1) personal relevance, (2) scientific uncertainty, (3) critical voice, (4) shared control, and (5) student negotiation. Other data sources came from classroom assignments, semi-structured interviews conducted after observations and classroom observations. However, each participant was only observed teaching a self-selected constructivist lesson. As a result, the authors may not find much inconsistency between teachers' beliefs and practice.

In their study, Haney and McArthur (2002) analyzed teacher beliefs as either core beliefs or peripheral beliefs. Core beliefs are defined as those beliefs that are both stated and enacted, while peripheral beliefs are defined as constructivist beliefs that are stated but are not enacted. The study showed that teachers' core beliefs (constructivist, conflict and emerging) were stable and resistant to change. Teachers' beliefs regarding personal relevance, scientific uncertainty, and student negotiation were constructivist core beliefs that were consistent with their practices. However, shared control was a peripheral belief for three teachers who stated that they would like to implement it, but they found it both difficult and frustrating to incorporate. The authors suggested that the belief, necessary to cover the existing local science curriculum, was evident as an obstacle for all participants.

Beck et al. (2000) conducted a study consisting of 203 teachers, having different backgrounds, teaching experiences and race, to identify the factors influencing K-12 science teachers' implementation of constructivism in their classrooms. The authors used an open-ended questionnaire and the Classroom Learning Environment Survey (Taylor et al. 1994) as instruments. In general, the teachers possessed positive attitudes about teaching for personal relevance, but teachers with Bachelor's and Master's degrees had a more positive attitude toward teaching for personal relevance than teachers with Doctoral degrees. Middle level teachers expressed their intent to teach for personal relevance more than primary teachers. Significant differences were found between teachers' intent to implement and their gender. Female teachers were more likely to implement the targeted behavior than male teachers for both critical voice and student negotiation. Middle level teachers were the most likely to implement student negotiation, while primary teachers had the most positive attitude about teaching for student negotiation. Generally, the teachers believed that teaching for personal relevance, scientific uncertainty, critical voice, shared control, and student negotiation in the classroom can motivate students, help students understand the limitations and imperfections in science, that science changes over time and involve students in their own learning. On the other hand, they also indicated that they were concerned with the amount of time, student misuse of critical voice, the immaturity and inexperience of students in the use of shared control and classroom management problems.

Haney et al. (1996) identified teacher beliefs and intentions regarding the implementation of science education reform strands. Data was obtained through structured interviews and questionnaires. Four questionnaires related to the reform strands of inquiry, knowledge,

conditions and applications were developed by the authors from the structured interviews conducted using a sample of 13 teachers. Findings indicated that women were more likely to intend to implement reforms strands than were men. The primary teachers held more favorable beliefs toward the implementation of science education reform strands than did the middle-level or high school teachers. Teacher familiarity was another component that influenced teacher intentions. Teachers in this study did not believe that they had the ability to bring about educational change. They believed that barriers such as lack of effective staff development opportunities, available resources and administrative support impeded their ability to implement educational reform. Although studies conducted by Beck et al. (2000) and Haney et al. (1996) could provide information of teacher beliefs about constructivism and science education reform strands, they provide little information about their actual classroom practice since the authors did no classroom observation. Levitt (2002) conducted a study in order to identify the beliefs of elementary teachers regarding the teaching and learning of science and the extent to which the teachers' beliefs were consistent with constructivism, which underlies science education reform. Sixteen teachers from two school districts involved in a local systemic project for science education reform participated in the study. Although data was collected via semi-structured interviews and classroom observations, each teacher was only observed teaching a single lesson from the program.

Levitt (2002) categorized teacher beliefs and classroom practice into three groups: traditional, transitional and transformational. The author concluded that although gaps still exist between the teacher beliefs and the principles of reform, the implication of teacher beliefs is that the teachers are moving in a direction consistent with science education reform. The author described teacher beliefs as incomplete when compared to the philosophy of teaching and learning underlying science education reform. On the other hand, the findings of the study could not give in-depth information regarding teacher-classroom practices due to few classroom observation hours.

A more recent study was done by Roehrig and Kruse (2005) in order to understand the impact of a reform-based chemistry curriculum on teachers' classroom practices and to identify the effects of teacher beliefs and knowledge on their implementation of the curriculum. Twelve high school chemistry teachers participated in the study. Data was collected through interviews and classroom observations from the field test of the curriculum prior to full implementation. Participant responses were categorized as traditional, instructive, transitional, responsive or reform-based and then given a numerical value from 1 (traditional) to 5 (reform-based). In addition, each teacher was observed teaching non-LBC lessons at least twice prior to the field test of LBC and observed weekly, totaling four-to-seven observations per teacher. The findings of the study revealed that teachers' classroom practices became more reform-based as a result of the presence of the new curriculum. This study is also consistent with the idea that teaching beliefs have a significant influence on classroom practices. Experienced, out-of-discipline teachers with transitional or student-centered teaching beliefs exhibited the most growth in reform-based teaching practices.

The studies previously discussed found that teacher beliefs are mostly consistent with their practice. However, most of these studies have collected self-reported data by rating their use of teaching strategies without observation (Beck et al., 2000; Haney et al., 1996; Hashweh, 1996); or limited observation (Haney & McArthur, 2002; Levitt, 2002; Roehrig & Kruse, 2005). Therefore, this can be one of the reasons that they have found consistency between

their beliefs and practice. On the other hand, studies investigating the relationship between teacher beliefs and practice should consider the context in which teachers work in order to better understand the relationship. There have been some studies that teacher beliefs do not necessarily influence classroom practice because of several factors (Hancock & Gallard, 2004; Mellado, 1998). Teacher education and teacher background, school community including administrator, parent and student perspectives and other factors such as the need to cover curriculum and preparing students on exams are some of the possible factors that may influence teacher classroom practice as well as teachers' beliefs about teaching and learning, and should be taken into account by researchers.

Teacher Education

Some studies show that although teachers have student-centered teaching and learning beliefs, they may not be able to implement their beliefs into their classroom practice because of the inadequate practical knowledge needed in the classroom. For example, Mellado (1998) conducted a study with 4 student teachers in Spain to investigate the relationship between pre-service teacher conceptions of science teaching and learning and their classroom practices. The data gathering procedures included a questionnaire and interviews, both analyzed by means of cognitive maps and classroom observations during the participants' practice teaching. Each participant was observed teaching the same subject for one or two classroom sessions. The authors could not find any clear relationship between the teachers' conceptions about teaching and learning of science and their classroom practices. The authors believe that the reason could be due to the fact that the knowledge the teachers received concerning science education was theoretical, impersonal and static with little relationship to the practical knowledge needed in the classroom.

Similarly, Hancock and Gallard (2004) conducted a study with 16 pre-service teachers in an undergraduate science education methods course that involved observation and teaching experiences in K-12 classrooms in order to understand the impact of field experiences on the beliefs developed by pre-service science teachers. Data was gathered through drawings representing beliefs and in-depth interviews with 5 participants. The findings of the study revealed that field experiences both reinforce and challenge the beliefs held by pre-service teachers.

One of the studies that showed an inconsistency between teacher beliefs and classroom practices was done by Simmons et al. (1999) as a part of the Salish I Research Project. Nine university research sites selected 10 beginning teachers who were graduates of the participating university. A total of 116 beginning teachers participated in the study. Data was collected from interviews, classroom observations and the Constructivist Learning Environment Survey developed by Taylor et al. The authors categorized teacher beliefs as student-centered beliefs or teacher-centered beliefs. Although many beginning teachers hold student-centered beliefs, only 10% of first-year teachers implemented student-centered, inquiry-based instruction.

School Community

Identifying the beliefs of the school community as well as those of teachers is important for successfully implementing reform in schools. Haney et al. (2003) focused on a constructivist learning environment not only from the teacher's perspective, but also from that of the administrator, parent, community member and student. Seventy-two participants of a year-long Eisenhower-funded project were purposefully selected for this study. The participants represented school community groups: 35 teachers, 9 administrators, 18 parents/community members and 10 students. The authors asked a single open-ended statement for participants to complete: "My perception of the relationship between students and teachers in the learning environment is _____." Responses were rated using a rubric with a 1-to-5 point system for a statistical analysis. The findings of this study indicated that even though both administrators and teachers significantly held more positive beliefs than did the parent/community members, constructivist teaching ideas did not dominate their beliefs regarding successful teaching. Constructivist beliefs especially related to curriculum, use of instructional strategies and assessment techniques seemed to be lacking. Administrators reported significantly higher constructivist beliefs than did the parents/community members or students regarding the teaching for understanding construct including teacher as facilitator, student preconceptions and relevance, higher order thinking skills, demonstration of understanding and construction of student conceptual understanding. This finding is somewhat contradictory to the findings of previous studies (Haney et al. 1996) that teachers do not have administrative support while trying to implement constructivist reform. One reason for this discrepancy could be that the administrators in this study were involved in science professional development projects. This study reveals that the beliefs of the school community might be another factor that may affect teacher classroom practices.

Other factors

Roehrig and Luft (2004) investigated the constraints that beginning secondary science teachers experienced in the implementation of inquiry-based lessons while they participated in a science-focused induction program. Data was collected via multiple sources including demographic information, open-ended and semi-structured interviews about teaching beliefs, monthly classroom observations and a nature of science questionnaire. Teacher beliefs were captured using an open-ended interview at the beginning and end of the school year. Participants' responses at interviews were categorized as didactic, transitional, conceptual, early constructivist, experienced constructivist or constructivist inquiry beliefs. Didactic and transitional responses represent teacher-centered beliefs, while early constructivist, experienced constructivist or constructivist inquiry responses represent student-centered beliefs. Each teacher was observed at least seven times during the school year by project staff. The authors categorized three broad groupings that emerged to represent the experiences, knowledge, beliefs and practices of these teachers: inquiry teachers, process-oriented teachers and traditional teachers. According to these results, four teachers were described as inquiry teachers as they implemented inquiry in their classrooms. Two of the teachers believed that science class consisted predominantly of activities and laboratories for students to learn science process skills. Eight teachers fell into the traditional group.

The results showed that none of the factors including teachers' content knowledge, views on the nature of science, teaching beliefs and pedagogical knowledge in isolation were found to be predictive of the implementation of inquiry-based instruction. Strong content knowledge combined with student-centered beliefs and a contemporary view of the nature of science increased the possibility that inquiry would be implemented in the classroom. Other constraints to implementing inquiry instruction became evident as the beginning science teachers were observed and interviewed during post-conferences. The most prevalent self-reported constraint among the beginning teachers was low student ability and motivation. Another constraint reported in this study was the management risk of science as inquiry.

In addition, Tobin and McRobbie (1996) investigated the enacted science curriculum and factors that impede reforms in secondary science classes. In their study, data was collected from a chemistry teacher and his eleventh-grade students using the Classroom Environment Survey developed by Tobin, classroom observations and interviews. The authors identified four cultural myths that were supported by both the teacher and students including the transmission of knowledge, being efficient, maintaining the rigor of the curriculum and preparing students to be successful on examinations. The transmission myth views the teacher as a transmitter of knowledge and students as receivers of knowledge. The efficiency myth expresses the beliefs that teachers have control of students and covering content is more important than student learning. The myth of rigor includes the beliefs that the teacher's role is to identify the content to be learned and decide what tasks are appropriate for students. Tests and examinations are focused on in the enacted curriculum and result in an emphasis on low cognitive-level types of engagement by students. The authors discussed that these beliefs are obstacles to the reform of science education and should be addressed to facilitate the implementation of reform in science classrooms.

Conclusion

Teacher beliefs are receiving a great attention from the education community and have been discussed widely in the literature ranging from philosophical discussion to experimental studies (Calderhead, 1996; Fang, 1996; Kagan, 1992;Mansour, 2009; Nespor, 1987; Pajares, 1992; Richardson, 1996; Woolfolk-Hoy & Murphy, 2001). On the other hand, beliefs have a variety of definitions in the literature and have been used interchangeably with knowledge. The first part of the literature compares definitions of beliefs and knowledge and clarifies the distinction between these terms. Richardson distinguished knowledge from beliefs based on the notion of "truth condition." In her definition, knowledge must satisfy "truth condition" or have some evidence but beliefs do not require a truth condition. According to Calderhead, beliefs generally refer to, "suppositions, commitments, and ideologies while knowledge refers to factual propositions and the understandings that inform skillful action" (p. 715).

The second part of the literature review focuses on studies related to teacher beliefs and classroom practice. In the literature the relationship between teacher beliefs and classroom practice has been widely discussed. While some studies (Beck et al., 2000; Haney et al., 1996; Haney & McArthur, 2002; Hashweh, 1996; Levitt, 2002; Roehrig, & Kruse, 2005) found that teacher beliefs have a significant relationship with classroom practice, others (Mellado, 1998; Simmons et al., 1999) did not find a clear relationship between teacher beliefs and practice. The relationship between teacher beliefs and practice is controversial; regardless, beliefs

ultimately connect to teaching practice (Richardson, 1996; Roehrig & Luft, 2004). Although there has been more research related to student teachers and beginning teachers, research with in-service teachers in classroom settings seems to be relatively sparse. In addition, most of the research with in-service science teachers collected self-reported data through surveys regarding their classroom practice without classroom observations (Beck et al.; Hancock & Gallard; Haney et al.; Hashweh) or with few observations (Haney & MacArthur; Mellado;). As Fang (1996) indicated, self-reported data without classroom observation may reflect what should be done (preferred classroom practice) rather than what is actually done in practice (actual practice). In-depth research that combines survey information with a long period of classroom observations is needed to fill this gap in this area. Therefore, case studies and longitudinal studies with a small number of participants seem to be more valuable in order to understand the complex relationship among teacher beliefs, practice and school context.

Moreover, other factors including teacher education, teacher content and pedagogical content knowledge, school type and grade levels, school resources as well as teacher beliefs should be investigated. Therefore, researchers should design multiple studies in different school settings such as public versus private, primary school versus secondary school, and rural school versus urban school. These types of studies may help scholars to understand how school context could affect teacher classroom practice even if they have similar beliefs and backgrounds. In addition, more longitudinal studies with student teachers should be conducted from the beginning of their teacher education to their early experiences as beginning school teachers in order to understand how their beliefs change over a long period of time and how this change influences their actual practice.

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