Consistencies and inconsistencies between science teachers' beliefs and practices

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Abstract

To gain a better understanding of teachers' beliefs about teaching, as compared with their in-reality classroom practices, case studies were constructed with four science teachers in different schools in Egypt. The main aims of this paper were to provide an answer to the research question, "How far do science teachers' classroom practices reflect their beliefs?" and to explore the contextual factors that can explain the difference, the consistency or inconsistency, between teachers' beliefs and practices. The study collected data for each teacher using semi-structured interviews, notes taken while observing classes, and teachers' notes, journals and lesson plans concerned with STS lessons. The data were analysed using the constant comparative method around common themes, which were identified as distinctive features of teachers' beliefs; these same themes were then compared with their practices. Results showed that a few of the in-service science teachers' pedagogical beliefs aligned with constructivist philosophy. Some of the teachers' beliefs were consistent with their practices, especially the traditional beliefs, while some of teachers' practices were conflicted with their beliefs in different contexts.

Introduction

For decades, many research studies have focused on identifying factors that shape what teachers do in the classroom. Some of these factors include goals for student learning, perceptions about students, the contexts of teaching (Clark & Peterson, 1986; Tobin, Tippins, & Gallard, 1994; Schoenfeld, 2002; Kang & Wallace, 2005), and beliefs about the nature of science and the subject matter (Gess-Newsome & Lederman, 1994; Hammer, 1995; Abd-El-Khalick, Bell, & Lederman, 1998; Abd-El-Khalick & Lederman, 2000); also the curriculum (Cronin-Jones, 1991; Author, 2010) and socio-cultural contexts (Vygotsky, 1978; Ajzen, 2002; Author, 2008, 2010, 2012). Given the numerous factors, research reports inconsistent results about the relationship between beliefs and teaching practices indicating that teachers' beliefs do not necessarily have a direct causal bearing on their actions (Tobin, Tippins, & Gallard, 1994). Yet educational scholars maintain that in actuality we know little about the extent of teachers' beliefs and the nature of the relationship between beliefs and teaching practice (Laplante, 1997; Haney, Lumpe, & Czerniak, 2002; Bryan, 2003).

The studies about teacher beliefs about teaching and their actions provide background knowledge for the next step in the further understanding of teaching practices (Luft, 1999; Levitt, 2001; Tsai, 2002; Kang & Wallace, 2005). This study addresses several gaps in the current literature on science teacher beliefs. First, it focuses on the beliefs of both novice and experienced science teachers. This will offer a chance to examine the changes that might happen to teachers' beliefs and practices as a result of training and experience (Brickhouse, 1990; Richardson, 1996; Calderhead, 1996; Bryan, 2003); the ideal is to explore beliefs during the different stages of a teacher's career. Second, this study also responds to the need for more studies conducted at the middle level of schooling, after primary school. Indeed, understanding teachers' beliefs about science teaching and learning will help science educators determine the types of experiences that are important for these teachers as they enter the profession (Bryan, 2003) or are in the educational system for long time. Third, among the many areas of teacher beliefs, this study focuses on how teachers relate their epistemological beliefs to their beliefs about learning and teaching science and to what extent these beliefs are consistent with their practices in the classroom. Fourth, many research studies have focused on identifying the relationship between teacher beliefs and practices (Brickhouse, 1990; Luft, 1999; Tsai, 2002; Bryan, 2003; Brown & Melear, 2006; Savasci & Berlin, 2012) but the current study emphasises the role of socio-cultural contexts in understanding the relationship between beliefs and practices. The study focuses on understanding the contextual factors that explain why teachers adopt different teaching practices in their particular teaching contexts and why some teachers' practices do match with some of their beliefs but do not match with other beliefs. Further, this study focused on teachers' teaching actions around STS issues.

Teacher beliefs

Several works provide a definition of beliefs from different theoretical perspectives and disciplines, including "belief is used to characterize a teacher's idiosyncratic unity of thought about objects, people, and events, and their characteristic relationships that affect his/her planning and interactive thoughts and decisions" (Author, 2009, p. 26). Beliefs are "psychologically held understandings, premises, or propositions about the world that are felt to be true" (Richardson, 1996, p. 103). Pajares (1992) asserted that beliefs are ''the best indicators of the decisions individuals make throughout their lives'' (p. 307). However, there is still much debate as to whether pedagogical beliefs influence actions or actions influence beliefs. For example, Pajares (1992) supports the notion that pedagogical beliefs held by teachers influence their behaviour in the classroom. In short, people act upon what they believe. Ernest (1988) also argued that teachers' beliefs have a powerful impact on the practice of teaching. In the same vein, Clark and Peterson (1986) described teachers' beliefs and theories as "the rich store of knowledge that teachers have that affects their planning and their interactive thoughts and decisions" (p. 258). Bryan and Atwater (2002) argue that these teachers use these provisions that act as knowledge and belief systems to create models that serve as representations for things. These things can include ideas about people and their behaviour. Teacher's beliefs have an impact on the quality of science learning occurring in classrooms. Vygotsky (1978) added a social aspect to teacher beliefs by including the interconnected inferences in how a person constructs themselves in relation to the world. From his or her own belief constructs, a person will base his actions. In addition to Vygotsky's social views about teacher beliefs, Kagan's (1990) definition of teacher belief about teaching and learning STS issues is compatible with the scope of this study: "the highly personal ways in which a teacher understands classrooms, students, the nature of learning and the teacher's role in the classroom" (p. 423).

Relationship between beliefs and practice in science education and STS research

In reviewing the research literature in science education, I found that the relationship between teachers' beliefs about ideals and goals for teaching and their in-reality teaching practices was open to debate. A wealth of research evidence has shown that teachers' beliefs about teaching and the learning of science influence their teaching practices (Fang, 1996; Brickhouse, 1989, 1990; Brickhouse, Bodner & Neie, 1987; Laplante, 1997). Through their work with the theory of planned behaviour, Haney, Czerniak, and Lumpe (1996) determined that teachers' beliefs are significant indicators of the behaviours that will be present in the classroom. Teachers' beliefs about the subject matter have also been found to influence day-to-day decisions about what to teach, what to skip, and how much class time to devote to a particular topic (Cronin-Jones, 1991).

Although much research (Pajares, 1992; Calderhead, 1996; Fang, 1996) has indicated that teachers' classroom practice is influenced by their beliefs, there is still a need to examine teachers' beliefs in order to clarify how they affect their practice. Poulson et al. (2001) pointed out that the relationship between teachers' beliefs and practice is complex, and explain that it is "dialectical" rather than "unilateral"; therefore practice does not always come after beliefs. Nespor (1987) explains how beliefs become personal pedagogies or theories to guide teachers' practices: teachers' beliefs play a major role in defining teaching tasks and organizing the knowledge and information relevant to those tasks. A study by Lumpe, Haney, and Czerniak (1998) identified teachers' beliefs and found that they believed the inclusion of STS could develop decision-making skills in students and provide meaningful applications of science to real life. However, their concern lay in the time it took to do this type of teaching and learning, as well as the controversial issues that were involved in some STS themes. Identifying these concerns was important because they might inform the beliefs that teachers held toward STS themes, and the practices that occurred in the classroom.

There is a complex interaction between teacher beliefs, which are sociocultural construct, and teacher actions, which take place in the social arena. One view is that teacher actions represent one aspect of a teacher's beliefs and should not be perceived as a separate entity from their belief system as a whole. What a teacher actually does in the classroom is representative of her beliefs (Wallace & Kang, 2004). Brickhouse et al. (1987) found that one teacher who believed that "quantification differentiates science from non-science" (p. 44) placed "a great deal of emphasis on quantification" (p. 37) in instruction. Another teacher believed that "science is discovered" and used this as a rationale for discovery labs, "which give the students an opportunity to be discoverers" (p. 44). In another study with three secondary school teachers, Brickhouse (1990) described how a teacher who viewed theories as truths wanted his students to know about the major scientific theories. A second teacher who considered theories as tools insisted that his students should be able to use them to solve problems. A third teacher viewed "the scientific method" to be a linear and rational process "that leads on unambiguously to scientific truth", also believed "scientific procedures to be predetermined" (p. 55), and held that "science activities require following directions to get correct answers" (p. 56). However, the other set of research indicates that teacher behaviour is not always consistent with their beliefs. For example, Galton and Simon (1980) indicated that the relationship between teachers' beliefs and their practices was not very strong. As Fang (1996) suggested, there may be inconsistencies between teachers' beliefs and practices due to the complexities of classroom life, which may constrain teachers' abilities to follow their beliefs and provide instruction that is aligned with their theoretical beliefs. Teachers' theoretical beliefs could be situational and manifested in instructional practices only in relation to the complexities of the classroom. Kang & Wallace (2005) worked with three experienced secondary school science teachers and revealed that a teacher's sophisticated epistemological beliefs were not always clearly connected to their practice. In addition, Brown and Melear (2006) analyzed links between the teachers' conveyed beliefs and observed practice regarding both the teachers' actions and the students' actions. They found inconsistencies between interview and observational data due to the physical environment and administrative duties. These results were reached by King, Shumow, & Lietz (2001) who indicated that there was a disconnection between what the teachers said they did versus what observers saw them doing in the classroom. Teachers' beliefs about science teaching are extremely varied. Some teachers believe in teaching students by lecturing or direct teaching. Others reflect constructivist views of learning and teaching, by using cooperative learning or enquiry. However, the majority of science teachers are more likely to mix features of different science teaching methods.

Moving from the traditional transmissional teaching mode to constructivist teaching

Current reform in science education requires teachers to depart from the traditional transmissional teaching mode to constructivist teaching in which students' multiple meaning constructions are acknowledged, and understanding of the nature of science through the experience of science enquiry is promoted (Duit, Häußler, Lauterbach, Mikelskis & Westphal, 1992; Tobin, 1994; Watts, 1994; Beck, Czerniak, & Lumpe, 2000; Levitt, 2001). In his study, Tairab (2001) found that the views of a majority of the participating science teachers were divided between content-oriented and process-oriented science. Generally such views were spread between a naive perspective of "science as a study of fields such as biology, chemistry and physics" to a more realistic view that regarded science as a process-oriented human activity. Also, the views of the science teachers who participated in Tairab's study regarding the nature of technology confirmed the concern highlighted by Aikenhead and Ryan (1989) that the instrumentalist view often confused science with technology, with regard to the social purpose of both. In his review of literature on teachers' beliefs and knowledge Calderhead (1996) summarized beliefs related to teaching and learning. He placed teachers' beliefs into two categories by arguing that while some teachers view teaching as a process of knowledge transmission, others view it as a process of guiding children's learning or as a process of developing social relationships.

In the traditional model, it is assumed that an already developed body of knowledge, one generally accepted by the scientific community, can be transmitted to students through passive instructional means. What is known about learning, however, demonstrates that passive instruction is an ineffective tool for learning science concepts (Tobin et al, 1994, cited in Levitt, 2001). The central question of enquiry is: how and in what way should students learn science? Segal (1997) argues that many science-alienated students have experienced didactic, teacher-dominated lessons where science is transmitted in a monologic fashion, exclusive of learners' interests, background experiences or preferences. In addition in this traditional model, evaluation of learning emphasizes summative assessment; knowledge has either been transferred or it has not. The teacher is seen as being the active transmitter of knowledge. The pupil is initially empty-headed and plays an intellectually passive role in adopting that knowledge. Fox (1983) uses the term "transfer theory" to refer to teachers within the transmission mode. He suggests that teachers who adopt the transfer theory tend to express their view of teaching in terms of "imparting knowledge", "conveying information", "giving the facts", or "putting over ideas". Two of the teaching methods, the lecture and the "chalk-and-talk" approach, represent the classical ways of seeing the transfer or transmission theory in action (Bentley & Watts, 1989).

In contrast to the transmission view, there is a constructivist view about teaching/learning science. Gruender and Tobin (1991) consider constructivism in science education as the most important contribution of the last two decades. What we call a constructivist approach in science education is a proposal that contemplates active participation of students in the construction of knowledge and not the simple personal reconstruction of previously elaborated knowledge provided by the teacher or by the textbook (Gil-Pérez et al., 2002). In its many different forms (from a Piagetian notion of an individual's adaptation and assimilation of new information to an emphasis on learning as the product of complex socio-cultural processes, as suggested by Bruner, Lave, Rogoff, and Vygotsky), the learner is an active participant. Learning is thus viewed as encounters between individuals and the world in a social and historical context (Wickman & östman, 2002). As such, they are involved in the interpretation of meaning, the reflection of experience and the construction of the experience to become more knowing (Garbett, 2011). As explained by Jenkins (2000) a constructivist view of learning entails engaging students in practical activities. If, as constructivism requires, learning presupposes the active engagement of the mind of the learner, then the notion of "passive learning" lacks meaning.

Within the sociocultural view, learning is situated within the interplay of micro and macro level processes by examining social activity in its cultural and historical context (Cole 1996, Vygotsky 1978, Wertsch 1991). Learning is accomplished as the learners participate in the communal cognitive activity. The factual basis of knowledge is important, but this factual basis only becomes knowledge when a learner puts it in a relevant context (Seay, 2004). In this sense, science needs to be relevant to students' everyday lives since this real context provides the roots from which their studies should be drawn. The movement for relevance helps to shape school science in the United Kingdom throughout the 1980s so that schemes like SATIS (Science and Technology in Society) were motivated by the need to relate the "application" of science to current issues in society. In this sense, science-as-social-practices constructivism is a view accepted by almost everyone, that science is created through human activity (Kelly, 1997). From a constructivist perspective, learning is viewed as the active construction of knowledge in gradually expanding networks of ideas through interaction with others and materials in the environment (Marshall, 1992). Constructivism places primary emphasis on the independence of each person's interpretation of his or her own experience (Roth, 1994).

The role of socio-cultural contexts in the relationship between beliefs and practices

Culture and cultural knowledge play an integral role in knowledge construction, particularly in science and science education (Bryan & Atwater, 2002, p.6). A number of studies argue that teachers' beliefs and practices cannot be examined out of context (e.g. Fang, 1996; Pajares, 1992, Falcão, 2008, Jones & Carter, 2009, Author, 2012), but are always situated in a physical setting in which constraints, opportunities or external influences may derive from sources at various levels, such as the individual classroom, the principal, the school, the curriculum, or the community (Cronin-Jones, 1991; Ajzen, 2002). Teachers' beliefs are influenced by the interaction within the nested social contexts within which the beliefs and practices are situated. Rogoff (2003) argues that people develop as participants in cultural communities. Their development can be understood only in light of the cultural practices and circumstances of their communities – which also change. (Rogoff, 2003, pp. 3-4).

Classrooms operate within institutions and suffer contextual constraints common to institutions, constraints that specify the roles, status and degree of autonomy that teachers and students are accorded. However, due to the diverse ways of living that teachers and students bring to teaching and learning, classrooms are also embedded in contexts in which learning is mediated by the social and cultural identities of participants (Bruner, 1996 cited in Brown & Redmond, 2008). The social norms of the school community influence how teachers believe their enacted practices will be perceived. For science teachers, this tension between beliefs and practices may arise when they are teaching about STS issues or controversial issues such as evolution (Jones & Carter, 2009). In this sense, Gwimbi and Monk (2003) argue that classroom circumstances might play a crucial role in determining a teacher's views on both teaching science and the nature of science.

Cross, 2004) has argued: 'Teaching' has no meaning in and by itself, and there is no 'one teacher' that has sole authority over absolutely everything related to the act of teaching. Teachers, their work (goals, activities) and how they do their work is derived from where they are situated within a wider social, cultural and historical context. (p. 34). It is therefore necessary to take into account the contextual factors that have shaped and formed certain beliefs. Thus, researchers must study the context-specific features of beliefs in terms of the connection of beliefs with other belief systems and contextual issues (Pajares, 1992). Nespor (1987) explains how the context plays the main role in forming teachers' beliefs: "the contexts and environments within which teachers work, and many of the problems they encounter, are ill-defined and deeply entangled; …beliefs are peculiarly suited for making sense of such contexts" (p. 324). Ajzen (2002) suggests that there are many elements that cause a mismatch between beliefs and practices. Real-life factors, such as learner behaviours, time, resources, and course content, have an impact on the degree of belief-practice consistency.

In the area of teaching/learning STS issues, the study by Pedersen and Totten (2001) of 37 science teachers, representing rural, urban and suburban areas, offers some major justifications as to why science teachers seem reluctant to discuss or teach STS issues. First, teachers believe that they lack outside support from parents and their community to do so; secondly they also believe that they lack the internal support of faculty and staff when attempting to implement controversial issues into their science curriculum. Thirdly, possible cultural expectations in the community may influence the development of teachers' curriculum; fourth, teachers are presenting students with information based on textbooks believed to be deficient in the area of social issues, although over 65 percent of teachers use them as the major guide for their curriculum. Fifth, teachers believe that neither pre- nor in-service teacher education offers adequate support for understanding social issues, and they rely instead on easily accessible sources for information on social issues. In their study of implementing STS education through action research, Pedretti and Hodson (1995) found that working with teachers might not always be sufficient, in itself, to effect significant change in implementing STS curricula. They argue that the structure of the school system – in particular, its bureaucracy, administrative procedures and values – can combine to create and sustain an institutional climate that is not favourable to, or supportive of, change. They also noted the many occasions when teachers are constrained from implementing a curriculum consistent with their personal beliefs about science and science education due to lack of time, an overcrowded syllabus, inadequate facilities, pressure of external examinations, or class management problems arising from unsupportive administrative structures.

Focus of the study

Increased focus on the use of constructivist instructional models as an agent of reform in science education has resulted in a great deal of research (e.g. Ravitz, Becker & Wong, 1998; Ogan-Bekiroglu & Akkoç, 2009; Savasci & Berlin, 2012). One major recommendation of these reports is the use of constructivist instructional models. Most of the studies in this area, however, are on the beliefs or perceptions of teachers about constructivist practices and a very few studies which really looked into the current practices which are consistent with constructivist teaching practices.

This study is a follow-up to a survey study (see: Author, 2010) which studied science teachers' perspectives on Science-Technology-Society (STS) in science education. This survey study investigates 162 preparatory Egyptian science teachers' beliefs about teaching and learning science through Science Technology and Society STS education. Data were collected using a questionnaire entitled Teacher's beliefs about Science, Technology and Society (STS) Education devised based on the review of relevant literature (e.g. Aikenhead & Ryan, 1989; Bybee & Mau, 1986; Levitt, 2001; Poulson et al., 2001; Rubba & Harkness, 1993; Tsai, 2002). The questionnaire consisted of 29 items included 27 closed- ended questions and two open-ended questions. The findings of this paper led to many questions that need further investigation. Firstly, teachers tended to respond to both the constructivist views and traditional views of the items in the questionnaire. This needs more investigation to discover why teachers tended to be inconsistent in their responses and why most of them seem to hold mixed beliefs. Secondly, the findings of the questionnaire shed light on some factors that face the teachers and act as barriers to putting their beliefs into practice, but we still need to understand how these factors operate to stop teachers from implementing their educational beliefs in the STS classroom. Understanding theses contextual factors might explain how we can help teachers to put their beliefs into practices. Also, the findings of the questionnaire questioned the relationship between belief and practice, whether it is consistent or inconsistent. Finally, the findings raise a question about the direction of the relationship between belief and practice; whether belief affects practice or practice can change belief. To get a deep understanding of all these issues that arose from the questionnaire findings, it is necessary to follow the interpretive paradigm in studying teachers' beliefs and practices (Munby, 1984).

Most of the research indicates that educational beliefs in general and teachers' beliefs in particular are not context-free (Gahin, 2001; Fang, 1996; Pajares, 1992). It is therefore necessary to take into account the contextual factors that have shaped and formed certain beliefs and practices. In the same respect, Calderhead (1996) indicates that teachers' beliefs and the context in which their beliefs are developed and used should be taken into consideration in order to have a better understanding of how teaching and learning occur in classrooms and can thus be enhanced. Therefore, the focus of this study was to understand how teachers make sense of their teaching practices in relation to their school and classroom contexts and characterize their own practices in relation to their expressed pedagogical beliefs. In so doing, this study focuses on why teachers adopt different teaching practices in their particular teaching contexts and why some teachers' practices do match with some of their beliefs but do not match with other beliefs. By linking teachers' beliefs to their classroom practice, this study will complement a body of literature on teacher beliefs and practices, and perhaps aid researchers interested in creating explanatory studies with specific constructs. Among the many areas of teacher beliefs and practices, this study focuses on how, and to what extent, in-service science teachers relate their pedagogical and epistemological beliefs about STS issues to their teaching practices.

Research questions

The main aim of this paper was to provide an answer to these research questions:

- What are the beliefs of the science teacher regarding teaching and learning STS issues?
- How far do science teachers' classroom practices reflect their pedagogical beliefs about STS?
- What are the contextual factors that can explain the difference, the consistency or inconsistency, between teachers' beliefs and practices?

Research methodology

Participants

As mentioned above this study was a follow up to a survey study (see: Author, 2010). The sampling was designed to include a broad spectrum of participants' experiences based on gender, unique teaching situations, a variety of teaching expertise, and various experiences teaching at different preparatory grade levels. The ten participants chosen for this study were gleaned from different preparatory schools, and represented all the grade levels, as well as a diversity of age and both genders. More specifically, the participants consisted of five males and five females, with teaching experience that varied from 12 to 34 years of teaching, and with ages ranging from the mid-thirties to early fifties.

According to the research aims and the research design, sampling procedures came in three stages. After analyzing the questionnaires (see Author, 2010), the maximum variation strategy was used to sample ten teachers with diverse beliefs. Then, based on the analysis of the semi-structured interviews with the ten teachers (Ahmad, Waheed, Marwa, V, Zaynab, Farida, Nagwa, Sami, Hesham and Basam), four teachers (Waheed, Farida, Zaynab and Mona) were chosen to represent the different relationships between teachers' beliefs and practices. The names of the participants are pseudonyms. I used alphabetical letters in referring to them so as to preserve the anonymity of the participants.

Data Collection

A multi-case study design was utilized for the research in order to focus on a belief–practice relationship within several cases. Thompson (1992) emphasized that inconsistencies between beliefs and observed practice could also be explained in part by the way teachers' beliefs were measured. In order to prevent any inconsistency between beliefs and practices because of the measurement, there was an attempt to use data from different sources to develop a detailed composite description of the in-service science teachers' beliefs and practices. The data were collected by using various sources, i.e., semi-structured interviews, observations, and in-service teachers' written documents such as lesson plans and reports of their lessons (Ogan-Bekiroglu & Akkoç, 2009).

Interviews: Three semi-structured interviews were conducted with each participant throughout the research. The purpose of the first interview was to determine the participants' pedagogical beliefs about teaching and learning science and their beliefs about STS issues. The second and third interviews were related to the participants' practices in the classroom and the school settings. These interviews were carried out in relation to the classroom observation and included stimulated-recall events from the classroom observation. The intention of the second and third interviews was to reveal the relationship between participants' pedagogical beliefs and practices.

Observations: In order to explore the participants' practices, they were observed by the author during their teaching. Each teaching session lasted 45 min. Descriptive field notes were taken throughout the observations.

Teacher Journals: Teachers record their personal observations and reflections of events in the classroom. These reports enriched the data as the researcher did not attend all the classes.

Data analysis

The interviews and observational data were coded and condensed into categories through several iterations (Miles & Huberman, 1994). The process of data analysis began with the first contact between the researcher and the participants. Data generated from each contact with the participants, through interview, observation, or the creation or review of documents, helped to form several tentative findings, which led me to probe some areas of discussion more deeply or change strategies for observation and data generation. This process of adjusting data generation procedures continued as additional data were generated and tested against the evolving themes. After each classroom observation and interview, I analysed the data before returning to the participant's school for the next round of classroom observations and interviews.

The study used the **constant comparative technique** which is considered a major technique used in grounded theory. Charmaz (2000) describes this method in the following way: The constant comparative technique means (a) comparing different people (such as their views, situations, actions, accounts, and experiences); (b) comparing data from the same individuals with themselves at different points in time; (c) comparing incident with incident; (d) comparing data with category; and (e) comparing a category with other categories (p. 515). During the interview phase of data collection, I focused on one participant at a time, comparing data taken from each teaching observation, and asking how the participant's teaching methods either supported or did not support their goals and purposes for teaching science. All the interviews lasted approximately 30-45 minutes, and each interviewee had around four to five observations and interviews.

Classroom observation aimed to ascertain the extent to which teachers' classroom practices are affected, or not, by their beliefs. To achieve this aim, the observational data were analysed for the key instructional episodes (Gahin, 2001). Examples of these practices included: presenting the interactive relationship between science, technology and society; students' roles; dealing with students' individual differences; strategies of teaching science through STS; the teacher's role; and using the evaluation on the class. The episodes were matched against the data obtained from the semi-interview, observation using Brown's instrument, and teachers' reflections in their journal on their lessons. The written notes were transcribed into Microsoft Word, read and reread, added to or compared with the domain analysis, and constantly compared to check patterns and themes. Thus, insight could be gained into the assumptions or factors behind teachers' practices and the associated contextual factors, and light could also be shed on the relationship between teachers' beliefs and their practices.

A "cross-case analysis" using the constant comparative technique (Miles & Huberman, 1994) of each participant's interviews was used to identify characteristics of teachers' beliefs in relation to their practices.In this stage, the data analysis focused on understanding how the categories related to each other, as well as on defining the direction of the relationship from one category to other. In comparing and linking the categories with one another, I was guided by what Glaser called "the Six Cs: Causes, Contexts, Contingencies, Consequences, Covariances, and Conditions" (1978: 74). For example, what are the consistencies and inconsistencies? What are the relationships between the different kinds of beliefs and practices? What are the contexts of these relationships? To explain the contextual settings of teacher beliefs and practices, I adapted a socio-pragmatic approach based on 'the action paradigm model' defined by Strauss and Corbin (1998). They used several generic notions related to action explanations, such as causal and intervening conditions, context, action/interactional strategies, and consequences.

This analysis led to a classification of the ten teachers into three dominant belief categories with regard to teaching and learning STS. These were along a continuum, from traditional to constructivist, with some teachers showing a mix of traditional and constructivist beliefs. Teachers' beliefs and practices were analysed in relation to Eight areas (See Table 1):

- The interactive relationship between Science, Technology and Society,
- Individual differences,
- the nature of scientific knowledge and the way to obtain it,
- Beliefs about STS learning,
- Teaching strategies of science through STS,
- Teacher role,
- The role of the student,
- Evaluation.

To differentiate among the different beliefs or practices (traditional-mixed-constructivist) of the teachers, the study used 60% as a cut off point. If 60% or more of teacher's beliefs and practices was coded into a specific category (constructivist or traditional) of the eight areas noted above, he or she was described as holding traditional beliefs, constructivist beliefs, traditional practices, or constructivist practices. Another descriptor emerged during the data analysis – this was mixed beliefs or practices. Teachers were described as having mixed beliefs or mixed practices if the same teacher espoused between 40-60% of beliefs or practices consistent with traditional ones and 40-60% of beliefs or practices consistent with constructivist ones.

After finishing the analysis and to be sure about what constituted a "traditional" teacher and a "constructivist" teacher, the study used a framework developed by Dancy and Henderson (2005) which described instructional practices and instructional beliefs associated with the teaching of introductory physics. This enabled a validation of the qualitative data analysis and to distinguish between the "traditional beliefs and practices" of traditional teachers and the "constructivist beliefs and practices" of constructivist teachers.

The main themes of this framework of instructional beliefs include (see Dancy and Henderson, 2005):

- Transmissionist learning views vs. constructivist learning views,
- Modernist knowledge views vs. Post-Modernist knowledge views,
- Role of schooling and STS education,
- Beliefs about students,
- Role of the teacher,

- Views on diversity, and
- Content goals of STS education vs. Process goals of physics education.

The main themes of this framework of instructional practices include (see Dancy and Henderson, 2005):

- Minimal degree of interactivity vs. Significant degree of interactivity,
- Teacher makes all instructional decisions vs. Students have input in instructional decisions,
- Fixed expectations of students vs. Adjustable expectations of students,
- Encourage or support competitive/individualist learning modes vs. Encourage or support cooperative learning modes,
- External motivators vs. Internal motivators,
- Knowledge-based assessment vs. Process-based assessment, and
- Knowledge-based content vs. Broad content.

Findings

The findings of the analysis indicated that the ten teachers could be classified according to their beliefs into three types; traditional transmission beliefs (Marwa, Waheed, Sami, Hesham, Nagwa and Basam), constructivist beliefs (Marwa), and combined (traditional-constructivist) beliefs (Zaynab, Ahmad and Farida). Features of each belief can be explained briefly as follows.

Individual teachers' belief patterns

*Traditional transmission beliefs in learning/teaching STS***.** According to the Dancy and Henderson (2005) framework, there appeared to be six teachers Waheed, Marwa, Nagwa, Sami, Hesham and Basam)), most of whose beliefs largely matched this type of belief system. For example, they appeared to believe that the lecture was the best teaching method for STS issues, and that a science teacher had all the responsibility with regard to teaching and learning – a view consistent with a teacher-centred orientation. In addition, they appeared to believe that it was the teacher's main responsibility to explain the STS issues in detail, and that the teacher should stick to what was contained in the textbook; these teachers were textbook-oriented.

*Constructivist beliefs in learning/teaching STS***.** As opposed to the former type, teacher Mona in this category tended to view teaching/ learning as a sharing process between the students and their teachers.

According to Reiss, a constructivist teacher is one who starts from the assumption that all pupils have their own ways of thinking, which they bring to science lessons and which they apply during their discussions in the science class. In this situation, the role of constructivist science teacher is to encourage these pupils to use their thinking and to help them to develop it (Reiss, 1993).

Combined beliefs (traditional-mixed-constructivist) in learning/teaching STS. This type of belief system includes various theories about learning and teaching science through STS. Three teachers from different schools, teachers Zaynab, Ahmad and Farida, held mixed beliefs which included both traditional and constructivist theories.

Individual teachers' practice systems

The findings of the analysis of the observations of teachers' practices indicated that the ten teachers could be classified into two groups – traditional practices Waheed, Marwa, Farida, Ahmad, Nagwa, Sami, Hesham and Basam)) and mixed practices (Zaynab, Mona) – and that none of the participants followed purely constructivist practice.*Traditional transmission practices in learning/teaching STS.* The practices of the majority of the teachers reflected behaviourist principles, with eight out of the ten teachers conducting classes in a teacher-centred pedagogy. They did most of the talking and they decided how class time would be spent. In all discussions, the teachers' ideas were dominant, and all were textbook-oriented. Evaluation and examination were the great aim for both teachers and students.

Constructivist practices in learning/teaching STS. None of the participants reflected an entirely constructivist approach to the classroom.

Combined practices (traditional-constructivist) in learning/teaching STS. Two of the teachers were observed to practise combined principles from both behaviourist activities (including transmission of knowledge from teacher to students) and constructivist activities (including active interaction between teacher and students). One of them, teacher Mona, held a mainly constructivist belief system while the other, teacher Zaynab, held combined beliefs (behaviourist-constructivist beliefs).

Relationship between teachers' beliefs and practices

Figure 1 shows the relationship between teachers' beliefs and practices. Four major types of relationships between beliefs and practices emerged;

Group I: teachers with traditional beliefs who were highly consistent in their traditional practices. This group consisted of six teachers Waheed, Marwa, Nagwa, Sami, Hesham and Basam).

Group II: teachers with mixed beliefs (traditional-constructivist) who applied traditional practices. This group consisted of just two teachers (Ahmad and Farida);

Group III: teachers with mixed beliefs (traditional-constructivist) who applied mixed practices. This group comprised teacher Zaynab only;

Group IV: teachers with constructivist beliefs who applied mixed practices. This group comprised teacher Mona who held mainly constructivist beliefs; her beliefs were inconsistent with some of her practices. The four groups can be represented as in Figure 1.

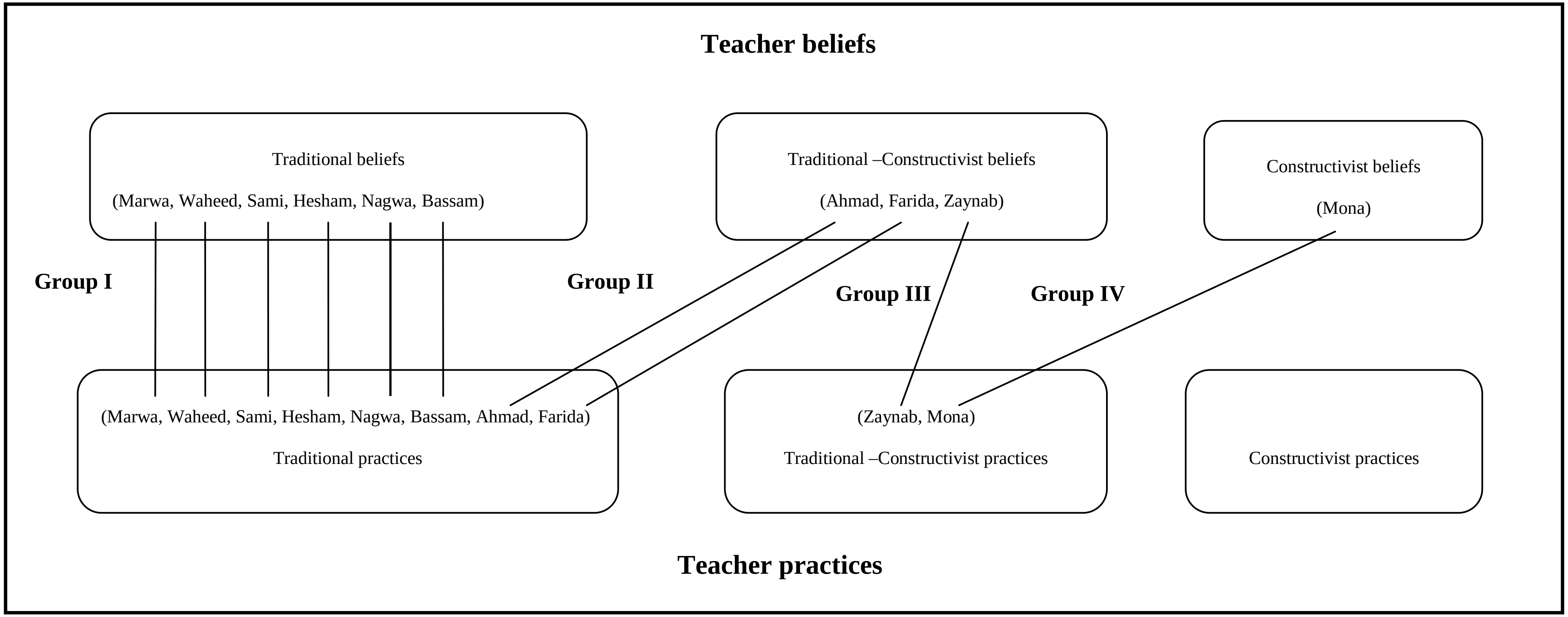

Figure 1: Relationship between teachers' beliefs and practices

To illustrate patterns of beliefs expressed by a particular group of teachers and to match that with their practice, one teacher from each pattern was used to represent the group of teachers. The representative teachers clearly portrayed the characteristics of the relationship between beliefs and practices about the teaching and learning of science through STS expressed by their respective groups. The focus of this paper, therefore, is on the four teachers who represented these relationships: Teacher Waheed represented group I (traditional beliefs/traditional practices); Teacher Farida represented group II (traditional beliefs/mixed practices), Teacher Zaynab represented group III (mixed beliefs/mixed practices), while Teacher Mona represented group IV (constructivist beliefs/mixed practices). The choice of each representative of each group was based on the teacher's commitment to me participating in the observation and on the rich data derived from his/her interview. Table 1 shows examples of the consistency and inconsistency in the four case studies' beliefs and practices. I use the terms "traditional," "mix" and "constructivist" as a way to differentiate teachers (see Table 1)

The data of each case study is presented through four main themes:

- the personal and professional contexts,
- the epistemology of science,
- Teaching science through STS, and
- Learning science through STS.

Table 1

Categorizations of relationship between beliefs and practices for the four case studies

case	clusters	Beliefs	Practices	Beliefs/Practices
W	STS	Science is a dominant aspect of STS (traditional)	Much focused on the scientific aspect (Primarily traditional)	Consistency (Primarily traditional)
	Nature of knowledge	Knowledge is valid, objective, cumulative (traditional)	Focus on the scientific aspect of STS (traditional)	Consistency (Primarily traditional)
	Individual differences	Students are different (constructivist)	Memorizing and adhering with content (traditional)	Inconsistency(Primarily traditional)
	Learning	Knowledge is transmitted to students (Primarily traditional)	One activity(traditional) (traditional)	Consistency (Primarily traditional)
	Teaching	Lecture style fits: content, student, teacher, aims (traditional)	Recitation and control the class (traditional)	Consistency (Primarily traditional)
	Teacher's roles	The teacher is responsible about teaching/learning (traditional)	Using lecture method (traditional)	Consistency (Primarily traditional)
	Students' roles	Student should be passive receiver (traditional)	Teacher-centred, Passive listening (traditional)	Consistency (Primarily traditional)
	Evaluation	Evaluation is to assess students' success (traditional)	Train students to answer questions(traditional)	Consistency (Primarily traditional)
F	STS	Cyclical-linear relationship STS (traditional)	STS-issue based approach (traditional)	Consistency (Primarily traditional)
	Nature of knowledge	Knowledge is discovered, objective cumulative (traditional)	Students observe experiments (traditional)	Consistency (Primarily traditional)
	Individual differences	Students are different (constructivist)	Multiple- activities and single activities by teacher (mix)	Mix
	Learning	Learning through group work; Learners active (constructivist)	Encourage students to know and understand (constructivist)	Consistency (Primarily traditional)
	Teaching	Let students ask; teaching STS based on students' knowledge (constructivist)	Teacher-focused and content oriented (traditional)	Inconsistency
	Teacher's roles	The teacher is guide, leader (constructivist)	Teacher-centred classroom (traditional)	Inconsistency
	Students' roles	Student should play an active role (constructivist)	Teacher played the main roles (traditional)	Inconsistency
	Evaluation	Evaluation is to assess students' success(traditional)	Train students to answer questions (traditional)	Consistency (Primarily traditional)
Z	STS	Cyclical-interactive relationship STS (constructivist)	STS-issue based approach (constructivist)	Consistency (Primarily constructivist)
	Nature of knowledge	Knowledge is a discovering process (traditional)	Teacher present experiments (traditional)	Consistency (Primarily traditional)
	Individual differences	Students have different mental abilities (constructivist)	Varying students roles with the main role for teacher (traditional)	Inconsistency
	Learning	Students' daily life and experiences (constructivist)	Encourage students to participate (constructivist)	Consistency (Primarily constructivist)
	Teaching	Science is taught through the interaction among students (constructivist)	Enquiry but textbook-oriented (mix)	Mix
	Teacher's roles	The teacher is facilitator, controller and a responsible for clarify and transfer knowledge, leader, (mix)	Facilitator, controller and guide (mix)	Mix
	Students' roles	Student should play an active role (constructivist)	Teacher planned all activities (traditional)	Inconsistency
	Evaluation	Evaluation is to assess students' success (traditional)	Exam-oriented (traditional)	Consistency (Primarily traditional)
V	STS	Cyclical-interactive relationship STS (constructivist)	STS-issue based approach (constructivist)	Consistency (Primarily constructivist)
	Nature of knowledge	Knowledge is constructed process (constructivist)	Teacher used cooperative learning (constructivist)	Consistency (Primarily constructivist)
	Individual differences	Every student learns differently (constructivist)	Varying students roles with the main role for teacher (mix)	Mix
	Learning	Learning through social atmosphere (constructivist)	Cooperative learning (mix)	Mix (Primarily constructivist)
	Teaching	No one specific teaching method for STS (constructivist)	A variety of teaching methods (mix)	Mix
	Teacher's roles	The teacher is facilitator, organiser and responsible for creating a learning environment. (constructivist)	All students express their views freely (constructivist)	Consistency (Primarily constructivist)
	Students' roles	Students should share ideas and learn from each other (constructivist)	Express ideas, do experiments (constructivist)	Consistency (Primarily constructivist)

	Evaluation	Understand the students' thinking about STS and create non judgement climate (constructivist)	Different levels of assessment and exam-oriented (traditional)	Inconsistency/ Consistency

Case studies

Case I: Teacher Waheed in Group I

The contexts for teacher Waheed

- Professional-academic context

Waheed obtained his Bachelor of Science and Education (Physics & Chemistry) in 1996, and a special diploma in Education 1998, and had been teaching science for eight years. His thesis for the degree of Master of Education was entitled, "The mental abilities and the psychological characteristics that are necessary for success in some science sections in the faculty of education". He had attended a workshop about using teaching methods effectively.

- The classroom context

Waheed taught in a class with desks arranged in the traditional fashion in which long rows of students' desks faced the main instructional area and the teacher's desk; i.e., all the students were facing the chalkboard. All teacher Waheed's science lessons, without exception, were taught in the classroom. He never used the laboratory, nor did he ever use any of the learning resources, even though there were several at the school, which, even if insufficient for individual work, could have been used for group demonstrations. He based all his lessons on the student textbook. When asked about this observation he replied,

What's important for the students is information, and taking the students to the laboratory wastes time, which can affect the amount of knowledge that should be imparted to them. Moreover, the students will ultimately be evaluated against the theoretical information in the textbook.

Waheed tried to maintain a controlled and disciplined atmosphere in which students were quiet and on task, and raised their hands before speaking. He said: "I will be a successful teacher if I can just control 45 students and get them to listen to me which is a very difficult job, more than the teaching process itself". His practices and comments showed that he believed that learning/teaching would be effective only if students were quiet, remained in their seats, and paid attention to his speaking all the time.

- The school context

Waheed worked in a small school with poor material resources. The focus of the school was on the cognitive success of the students. Teacher Waheed was not responsible for the examinations, which were organized by the senior teacher for all classes in the school. This focus on examinations created a competitive environment among students, with each other and also among the teachers. Waheed said: "As a teacher, I am controlled by an examination system which is imposed on me".

- The student context

Waheed's students were concerned about exams. This concern encouraged his traditional practices and may have helped to create consistency between his beliefs and practices.

- Personal context

He explained that he had been forced to enter the faculty of education, his family having pressured him to join the faculty in order to guarantee work. This was after his GSEC grade had prevented him from joining the Faculty of Medicine which was what he had wanted.

Waheed was not interested in the relationship between science and religion. He expressed a view that religion was the most important matter, not science, and argued that everyone should follow religion as much as they could. He felt that people's social life was organized by religion, which was why it was necessary to be careful in applying science to the society or in teaching science. He felt that it was his role to simplify the role of science in society as a servant for people. He also expressed his belief that religion was stable but science was not. These personal religious beliefs pushed teacher Waheed to be a direct transmitter of science and to use the lecture style to teach STS. (His teaching style in relation to his pedagogical beliefs is discussed in detail below.)

The epistemology of science

Waheed believed that science is content, "Science is a store of facts, concepts, principles and theories. This store is accumulative in nature". He saw the role of science education as being to help the learner to acquire and master knowledge, and this belief about the nature of science and the role of science education was reflected in his practice. It was also confirmed by analysis of his preparation notebook, which showed that 90% of his aims were based on knowledge acquisition and recall, which is the lowest cognitive level in Bloom's taxonomy of cognitive abilities.

It is clear that Waheed's epistemological view of science was characterized with positivism and that the role of the teacher and the students was not to build up knowledge but to know of and be convinced by the knowledge that scientists had produced. To Waheed this knowledge was seen as valid since it was agreed upon on by scientists. For example, in the lesson on the concept of "environmental balance", he built on the concept in his own words, and did not accept the pattern of definition that is based on induction. He asked students to adhere to and memorize the definition agreed upon by scientists, i.e., the one presented in the textbook. This was a major feature in this teacher's way of tackling lessons. He believed that scientific knowledge is valid and objective and that it should not be doubted, especially as it was based on experimentation.

Learning science through STS

In the first interview with teacher Waheed, he spoke of the objectives of STS learning: "The main aim is to make the students aware of what goes on around them. If a given problem isn't relevant to the students' interests today, it might still affect them later on". In the second interview, he said: "The teacher can teach the student to express his opinion and critical thinking, mostly within the formal content and not through public issues".

These beliefs about learning were inconsistent with his practices. This was obvious in his learning behavioural objectives in his notebook. In the lesson about "electrolysis" teacher Waheed put these aims: by the end of this lesson, students would be expected to know the concept of electrolysis; mention the parts of Hoffman's device; mention the equation for analyzing water with electricity; and mention three examples of the electric analysis process.

These objective aims implied that the content to be taught was fixed, static and must be transmitted. In other words, Waheed's learning objectives led to his way of choosing and dealing with classroom activities. The only activity he did with his students was the experiment. In the lesson about 'thermal degeneration', he did the experiment himself, emphasizing the changes that would occur to the substances. He directed students to observe the expected results of the experiment, and then presented the reaction equation and the importance of equating it. He did not mention real life situations that might reflect this reaction. He stressed the memorization by his students of chemical equations. In lessons that related to chemical reactions, Waheed adhered to the logical presentation of topics and the examples contained in the textbook.

Teaching science through STS

The way Waheed tackled the interactive relationship between science, technology and society was based on the content of the textbook. He pointed out this relationship only if it was directly included in the textbook itself. Waheeddescribed his teaching through STS as "lecture style", where he sat in front of the class and orchestrated a traditional recitation discussion, by presenting the STS issue, calling on students to answer questions, explaining and then giving students quiet time to work by themselves on the STS issue. There were several reasons prompting him to use the "lecture style" to teach STS, including his own knowledge about the STS issue under discussion, anxiety about teaching, and his subject specialization. After teaching STS lessons he commented in his journal that, *An STS issue can be a source of excitement and interest to the students but at the same time a source of anxiety to me if I'm not knowledgeable about its aspects. Many issues entail knowledge of more than one discipline, like biology, geography, sociology and geology. My specialization was in physics, so I use the lecturing teaching method when tackling the STS issues, which helps me to avoid being asked questions that I can't answer.*

One of the key influences on teacher Waheed's views and practices when teaching STS issues were the school textbooks and his cognitive orientation which was reflected on the lessons' learning aims. The observations of Waheed's classes in different grades and on different topics showed that W was cognitive aim-oriented, i.e., his teaching was controlled and directed by his aims that focused on the knowledge. The examples and activities he used were only the ones mentioned in the textbook. In a post-interview, Teacher Waheed justified the logic behind the way he tackled his lessons for some reasons (e.g.students' lack of experiences and knowledge related to the topics, lack of time or teaching skills to teach STS-problem based issues). Also Waheed emphasised that science teachers need a great deal of autonomy to be effective in the classroom and to be creative about the content and activities related to STS issues.

I think the way I taught the lesson was logical and suitable for the students' cognitive structure. What is of great importance is to build the cognitive base. If we begin with the topic in the form of a problem, we cannot reach the required cognitive base. Also, students lack experience. In addition, tackling the topic as a problem needs plenty of time, special teacher preparation, and further teaching skills. It also means that the teacher should be free to select the content, something that is not actually available.

Waheedwas aware of the problems of teaching STS issues with the lecture method and its effect on his students. He stated that:

Lecturing gives me a sense of safety even though it can be boring for the students. For example, the students were excited in the first ten minutes of the lesson about environmental balance, but then they began to lose their enthusiasm and some of them began to talk to each other. I could read boredom on the students' faces. This could have been for several reasons. One reason is that the students might have the same level of knowledge about the issue as the teacher, as a result of having had special lessons. Another reason could be that lecturing depends on direct explanation without getting students to participate. A third reason might be that I am conveying just the information in the textbook and using the same examples.

In the post-interviews we discussed his preference for teaching using this kind of "lecture" teaching method, even though he had said in the pre-interviews that "the STS issues required teaching methods like problem-solving and enquiry". He gave various justifications: (1) lecturing was economic in that it enabled the teacher to teach a great deal of content in a short time; (2) it allowed for the sequential presentation of the content; and (3) it was the method he had been used to from his student days both at school and at university.

Teacher Waheed also mentioned some teachers who had taught him in the past and who represented his role models. He therefore tried to copy them as they had influenced his beliefs and practices. He said that:

My teacher tried to bring science subjects alive for us. Every day he would do some kind of explanation and he read the textbook to help us and to show us how we could study. So, I am trying to imitate this teacher. He was a very good explainer and all the students liked him and a lot of student asked him to give them private tutorials, so I'd like to do that.

Teacher preparation at the university had also influenced his teaching style: "*In STS lessons and others, I often use the traditional teaching methods through which I was taught in the university. Switching to other teaching methods rather than the one(s) the teacher is used to needs time, in preparation and lesson planning".* He also highlighted time as a constraint on the use of STS and as a main reason for using the lecture method: "*One obstacle against the use of the STS approach is the limited class time. The teacher has to finish the topic in a given time. STS lessons often take much longer than traditional classes".* He noted in his journal that content was another obstacle to teaching STS: "Being obliged to teach a fixed content limits the teacher's freedom as to what and how to teach". When I discussed his plans for improving his teaching style with him, he said, "Perhaps things would be different if I used some other information resources and materials. Also, the textbook itself doesn't include any activities for the students to do, which makes them bored".

Waheed's teaching method affected his evaluation techniques, which focused on using short and direct questions to assess how much academic knowledge of the target issues had been achieved by the students. He gave them no chance to express themselves freely but told them to adhere to what he had taught them about the causes and consequences of the problem. He sometimes gave students incomplete answers, and insisted on the students completing them. Again, this contradicted what he had said in his interviews about the assessment that suited STS. His emphasis on training students about questions and the way to answer them was evident in all the classes I attended. His beliefs and practices regarding assessment were affected by his view of the ideal teacher, i.e., one whose teaching methods were based on asking and answering questions. Teacher Waheed's considered that this method prepared the students to do well to the final examinations and made them pay attention to the lesson.

Case II: Teacher Farida in Group II

The contexts for teacher Farida

- The professional-academic context

Farida was aged 55 and had obtained her first degree (BSc in Biology Education, 1976) from the Instruction and Curriculum department, Faculty of Education. She also had another degree (Bachelor of Chemistry, 1990) from the Chemistry department. She taught preparatory science curricula at the preparatory level, and chemistry curricula in secondary schools. She had attended many training workshops, e.g., on the National Standards for Education in Egypt and their application, and on computer and internet training.

Farida had spent three months in England on a training course at the University of East Anglia in Norwich. This had influenced and changed her beliefs and practices with regard to teaching/leaning science and her roles in the class. She said, "Before I went to England I had put all the emphasis on my work. Now I base my teaching on the students themselves. That is, I now help the student to learn by himself."

- Classroom context

Like other participants, teacher Farida had her classroom set up in the traditional manner. There were student desks in rows facing both the teacher's desk and the chalkboard.

- School context

Farida worked in a school that was rich in educational resources that included a knowledge resources room, a computer laboratory and a library. Such resources helped her with teaching the STS approach. However, she had to follow the textbook: "The current content is imposed on the teacher, and any drifting away from it is seen as a crime". Class time was not sufficient for teaching an STS issue. Farida was unable to employ most of what she had learnt in England. She said:

The administration didn't help me in this respect. In England, all science classes are taught in the lab and students do experiments themselves. The teacher only observes and guides. When I tried to apply this in Egypt the administration objected, stating that this was not suitable in the Egyptian school due to limited resources and space.

- Student context

Farida was teaching secondary school students. They were concerned about the exams and the questions they could expect in the final examination in order to gain high grades and go to a good university.

- Personal context

Farida had chosen the biology section because she liked to study plants and animals. Although her major subject was biology, she was appointed as a chemistry teacher in a secondary school because there was a shortage of chemistry teachers; this was why she had had to join the faculty of science to study chemistry. However, her experience of doing an MA thesis in the curriculum and teaching methods department affected her teaching performance greatly. Her practice became much more constructivist. One of the most powerful influences on Farida had been her former teachers, whom she met throughout the course of her education. She commented,

Before I joined the university, I had met different sorts of teachers. Some of those teachers used to offer help, expecting no return for this. Some other teachers offered help provided that one paid for them to do so (in the form of special tuition). I used to admire the first sort of teachers who were more enamoured by science. Those teachers encouraged me to choose to be a teacher so I could help anyone who needed scientific help.

The epistemology of science

Farida believed that science was "a type of knowledge which is discovered while doing experiments and grows by accumulation". This belief was reflected on her practice in class. She would ask her students to observe their experiments in the lab and write down all their observations. She said, "This trains students in accurate observation". In contrast to this process view of science, teacher F also expressed a constructivist view of science: "It's better for the scientist to work in a group rather than work individually. This generates creative ideas". Farida's beliefs regarding the importance of doing experiments in learning science through STS were reflected on her practices. For example, in a lesson on "electric poles", she emphasized the importance of experimentation in producing knowledge, learning the relativity of knowledge, and the importance of doubt.

Learning science through STS

Teacher Farida believed that a student's learning was her main responsibility. She stated, "If I don't thoroughly explain the lesson or topic to the students as it is in the textbook, the students wouldn't learn it". She was very aware of her responsibility to cover the Egyptian national curriculum to meet the requirements of the examinations. She believed that "mastering science concepts is the primary goal of science education in Egypt". This accorded with her belief about the importance of STS learning to enable the student to master the science content contained in the textbook: "Discussing these issues may distract the students so they will overlook the content on which they will be evaluated". In another interview she confirmed her view about using STS issues. She stated, "Such STS issues are only used for encouraging students and warming them up. I don't myself give these issues much space because the teacher is controlled by an evaluation system, which is imposed on him or her". In another interview, teacher Farida emphasized the necessity for students to master the scientific aspect in learning STS issues. She said:

If the student understands the relationship between science and technology, he will know that each technology has a scientific basis. Thus, the student's role will be the use of science in the production of technology. Also, if the student understands the relationship between science and technology, he will know that technology can be useful or harmful. Thus, he will think of producing technologies that do not harm society. In addition, the students' use of given technologies will depend on the characteristics of these technologies.

In contrast to Farida's traditional belief about learning STS, she also expressed some constructivist beliefs concerning learning STS. For Farida, students' motivation about and interests in the lesson are very important factors to ensure the students' engagements in the science classroom. She said:

The learner is the one who receives information. So if he has no desire or motive to learn, he won't understand the information presented to him by the teacher. For this reason, one of the teacher's responsibilities is to identify the characteristics of his students, so he can guide them.

Teachers Farida stressed the significant role of the pedagogy (e.g. debate, argumentation, cooperative learning) and the textbook (STS-based content) to motivate students and to engage them in the classroom.

A social problem has more than one aspect. So students should deal with more than one activity. Students can be divided into groups and each group can be given a task to perform. Different opinions on the different aspects of the problem are then discussed by the class. Also, groups can debate with each other.

The contents of the topics and the way they are organized play an important role in motivating students. And there should be a connection between what students learn at school and their lives outside school. That is, science should have a reflection on life. For instance, when teaching nuclear reactions, we should clarify the benefit and the seriousness of these reactions on the society.

Teacher Farida criticised the presentation of STS issues and the learning activities in textbooks. She emphasised the significant role of the learning activities that couldencourage effective discussion and dialogic talk. The content of the textbooks needs to be presented in a way to challenge the students' views and critical thinking and to develop the students' higher order thinking skills. She commented:

In the textbook the STS problem (e.g. pollution) is presented along with solutions. That is, solutions are imposed on students, and students aren't given the chance to think and propose solutions. It's better, therefore, when the activity can be presented without solutions and tools, so that students can think about the tools that are necessary for the activity.

Teaching science through STS

Teacher Farida holds constructivist beliefs concerning teaching STS. She views teaching through STS should based on the constructivist model in which students construct rather than receive or digest scientific knowledge She stressed the significant role that teachers can play to help students constructing the knowledge and engaging effectively in the classroom debating, arguing, discussing STS issues. Equally, she emphasised the important role that students play in the classroom (independent thinker, develop questions, reflects on ideas, etc) to take the lead to their learning. She commented:

Students and teachers should co-operate together to discover and construct the knowledge involved in STS issues. ...The teacher should encourage students to ask questions and to work in groups. …Students should play an active role in carrying out experiments and reaching their own conclusions. Teachers should just assist the students in developing new ideas. …The teacher should build on the planning and teaching of the STS issues on the basis of the students' knowledge and background about these issues.

In practice, teacher Farida put a lot of effort into implementing her teaching beliefs. Her treatment of STS issues took the form of issues or problems around which her lessons were developed, and through which the students were taught the knowledge content. During discussion of STS issues, she played the leader's role, guiding discussions and directing the students to the desired points. If the discussion faltered, she proposed new points, which helped students to take the target issue even further. For example, in the "oxygen" topic, she and the students discussed the issue of burning rice straw in fields, which pollutes very badly and reduces the amount of oxygen in the atmosphere. The students then suggested solutions to the problem, e.g., recycling the straw to convert it into fodder. In tackling this point, the students discussed the importance of oxygen and eventually came round to talking about the ozone layer, and then brainstorming about the causes of the hole in the ozone layer. Here her role was limited to clarifying the composition of the ozone layer, the way it is formed, and the causes of its deterioration.

Teacher Farida's beliefs about teaching and learning were in line with the evaluation techniques she used. To stimulate students' curiosity, she asked some open questions, which often excited the students and made them pay attention. She also used the traditional type of evaluation, i.e., closed questions, during all her lessons in the classroom to attract the students and make sure about what they had achieved. Even in the lessons that tackled STS issues or the relationship between science, technology and society, Farida focused only on science. This may have been due to the observation that she was exam-oriented.

It appeared that the pattern of the exams as set by the ministry was the main influence on teacher Farida's evaluation techniques. Furthermore, the evaluation technique she used conformed to the way she concentrated on the cognitive aspects of the issues. There was no summative evaluation or home assignment. She ended the class saying, "Any questions?" Then she asked the students to write the board summary in their notebooks. At the beginning of a new class, she did not ask the students about the problems they might have encountered as they studied at home or about the effect of the lesson topic on their lives.

Case III: Teacher Zaynab in Group III

The contexts of teacher Zaynab

- Professional-academic context

She had completed a Bachelor of Science and Education (Physics and Chemistry) in 1993 and held a special diploma in Education/MA. She had not studied STS at university or during her teacher training but had obtained her M.Ed degree and had been teaching science for eleven years. She had attended many training programmes about methods of teaching science, using computers to teach science, and how to use the science laboratory effectively in teaching. Her experience as a researcher had helped teacher Zaynab to manage her time and to overcome the constraints of materials, curriculum, class size, etc.

- Classroom context

Zaynab had a classroom that was set up in a traditional manner. There were student desks in rows that faced both the teacher's desk and the chalkboard. Most of Zaynab's lessons were in the laboratory, even though some of the lessons did not require experimentation. Teacher Zaynab remarked that, "all science lessons should be in the lab so the students can feel the scientific atmosphere".

There were no chairs for the students to sit on, so the students had to either stand all the time, or sit on the desks or on the floor under the desks. Nor was there a chair for the teacher. This kind of laboratory is not untypical of school labs in Egypt; in some schools there are labs called the "developed lab" where one can find around 15-20 chairs but this is still not enough for the typical Egyptian class size of 45-60 students. Also, like any other teacher, Zaynab had to give a lesson in the learning resources room once a week and to register this in her preparation notebook, regardless of the nature of the lesson and whether or not it was appropriate for it to be taught in that room.

- The school context

Zaynab's school was located in the countryside. The school administration was very supportive of Zaynab but there were not many resources in the school. In one interview, she said, "the computer lab isn't ready yet". She depended on natural resources, and used to ask her students to collect materials from their homes or from the environment around them.

- Student context

Zaynab's views of the diversity among students and the effect on their abilities influenced her teaching methods. She said:

Students are diverse and cannot be treated as if they were the same because actually they are not. They differ in many things like the social level of the family and achievement. ... Individual differences among the students should be met wisely by the teacher. The weak student should be given simple questions (e.g. questions that assess recall), whereas the brilliant student can be asked more difficult questions that suit his mental abilities. This is not to discourage the two sorts of students. And when explaining the lesson, the teacher should offer the brilliant student extended explanation and should be to the point with weak students. ...Students do not like direct teaching.

- Personal context

Zaynab has an open mind about having a basis of religion for everything. She said, "The problem in Egyptian society is that everything is weighed against religion". She had had a variety of experiences in her educational life which had helped her to build up her own identity as a teacher. She said, "I avoid the way some teachers treat their students. On the other hand, I have learnt from some other teachers how to treat students with respect and appreciation, and how to help them gain self-confidence."

The epistemology of science

Zaynab regarded science as the process of discovering new things about the world in which we live. She believed that the role of science education was to make the students acquire the skills of enquiry. This belief was reflected in her classroom practices and the aims she set for herself, as I realized when I analyzed her preparation notebook. It was evident that Zaynab's aims were oriented towards processes and discovering knowledge. She tried through the activities she did with the students in the lab to help them acquire scientific processes. For instance, in the lesson on "chemical reactions" she demonstrated by putting a magnesium film into plenty of oxygen and asked the students to describe what they observed. She then asked them to explain why the magnesium film had changed into white powder (magnesium oxide) and to compare the white powder (the outcome of the reaction) with the reactants. Following this, she asked them to deduce what had occurred and to express it by a chemical equation. In the lesson about 'oxygen', Zaynab burnt a pile of rice straw and asked the students to describe what they saw and to predict the results of the act of burning on oxygen. She also asked them to deduce the effect of that action on environmental balance.

Learning science through STS

Zaynab believed that teaching science through STS should be interesting and its relationship to students' daily lives made clear. She emphasized that the STS approach should involve active participation in classroom activities and discussions, and commented that participation could happen through cooperative learning:

It's very beneficial, especially if it's cooperative enquiry where students learn to play roles. Each student has a role to play and roles are switched. This makes students quite daring about expressing their opinions. Students learn cooperation and they help each other so the group can succeed in performing its task. This, in turn, reduces selfishness in some students.

However, no sign of cooperative group learning was observed in Zaynab's classes. Even though she stressed that social interaction should be an aim of science education there was no evidence of interaction among the students. All the interactions were between students and the teacher.

She emphasized the role of the teacher in dealing with students' experiences, saying "It is important for the teacher to know the students' experience and background knowledge, so s/he can tackle the problems at the level that suits them". In her own teaching, she asked the students to give examples from the environment around them, about all the different sorts of pollution they recognized and she encouraged them to talk about other things relevant to their lives, such as about any disease they or their relatives might have had.

Teaching science through STS

Zaynab's classes were mainly using inquiry based approach that engages students in investigating real world questions that they choose within the framework of the textbooks.. In all the classes I attended, she guided the students to discover knowledge by themselves, especially with regard to the lessons that related to the STS. The teacher played the role of facilitator who from time to time intervened to widen discussions and direct them as required so that students would keep to the point. Zaynab gave the students the chance to discover new things by themselves, encouraging them to discover knowledge, not to receive it as would be the case in traditional classrooms. The students applied processes of enquiry: they observed, hypothesized, described, predicted and deduced. Zaynab's teaching procedures were as follows:

- Presenting a situation that could prompt thinking and increase motivation.
- Urging the students to set hypotheses to interpret the situation.
- Asking the students about the consequences of an STS issue.
- Discussing the proposed solutions to the target STS issue and the role of everyone in society in the solution of the problem.

Students' autonomy was a key features of Zaynab's lessons. The students in Zaynab's classes were often free to express themselves without direct interference by the teacher. She would give the students enough time to do the required tasks. Although she performed the experiments and used the models by herself in all the classes, she urged the students to participate effectively and made them use their various mental abilities.

The way Zaynab tackled the STS issues conformed to the belief she had expressed in the pre-interview when she remarked that, *"The ideal classroom environment is the one where the students get involved in activities that relate directly to what goes on around them; this can stimulate their minds".*

The interviews also showed Zaynab's belief that science was best taught through STS by interacting with the students and by making the students interact with each other. She thought that students should be active participants:

In teaching by STS, a teacher needs to work closely with his/her students and interact with their ideas to correct them and to renew them. Also, the teacher should know what the students know about the STS issue *under study and use that as a starting point to create an interactive atmosphere among everyone in the class. Also it's the teacher's main task to find out what the students like, and how s/he can relate that issue to their interests.*

Observation of her classroom practices showed, to a large extent, consistency between what Zaynab said and what she did regarding her interaction with her students. However, it also showed a mismatch between what she said and what she did regarding interaction among the students. Observation indicated that the roles of Zaynab and her students differed according to the nature of the target task and the lesson. If an STS lesson included an experiment, the interaction between Zaynab and her students and their roles were different than if they were concluding knowledge.

Zaynab was also very textbook-oriented in all of her lessons and relied on the textbook as a main source of knowledge. She played the main role in collecting and analyzing the subject matter for her students. She noted many times in different interviews that because of the exams at half term or at the end of the academic year she tried to finish all the materials in the textbook. Moreover, Zaynab followed the traditional system of encouraging the students by giving them marks on the aural evaluation

Zaynab focused on the questions which assessed the science aspect only. This may have been due to her being exam-oriented and guided by the textbook. In this respect she stated; "Look at questions at the end of every unit, including the units that contain the lessons about pollution, and health. They assess the lowest level of achievement in Bloom's taxonomy, Recall. These questions represent models for both teachers and students". Zaynab also used to read sections from the textbook and as she read she clarified general points and from time to time identified possible questions that could be asked. She often asked her students to put an asterisk beside the important points in the content, saying "This point could be asked about in the exam and the question might be…" She commented on these practices;

Most parents have the idea that their children should be able to pass the final exams. They conclude that our work is not good enough unless their students get high marks and that is why most of the parents push their children to take private lessons. And of course in these private lessons the emphasis will be on the content, not on discussing STS issues or developing skills. The parents do not want to understand that the importance is for their children to be scientifically literate and be able to think. ... The curriculum in the preparatory stage focuses on knowledge. It doesn't include very many social problems. There are a few problems in the first grade like pollution, and one problem in the third grade, sound pollution. There aren't any problems in the second grade. In other words, the current curriculum isn't good in terms of the social problems it covers. Yet an interested and experienced teacher can relate some points in the curriculum to real life.

Case IV: Teacher Mona in Group IV

The contexts for teacher Mona

- Professional-academic context

Monahad obtained her Bachelor of Science and Education (Physics and Chemistry) in 1988, and a special diploma in Education in 1990, and had been teaching science for sixteen years. In 1997 she had been sent to King's College in London for a three-month training course. She had attended many workshops, e.g., training about the National Standards for Education in Egypt and their application, the internet and computer training. She had also trained in the effective use of the laboratory. Her three months' training in England had influenced her beliefs and practices towards the constructivist approach:

When I came back from England, I asked my colleagues to come into the classroom with me, especially in the cooperative learning classes. This type of teaching can be of great help to the weak students. I also noticed in England that teachers use several aids (e.g., the computer, videos, and demonstrations) in explaining lessons. This arouses students' interest and breaks the ice in the classroom.

Mona's pedagogical beliefs and practices had been greatly influenced by her experience with her teachers at university. She explained,

The professors of chemistry and physics from the Faculty of Science made me like science and believe in its value. Those professors were symbols to me as they devoted their lives to studying phenomena in the laboratory. They persisted in getting us to apply what we learnt. For instant, a physics professor used to tell us, 'You, as a physics teacher should be capable of repairing any broken machine in your house'.

- The classroom context

Mona had a classroom set up in the traditional manner. There were student desks in rows facing both the teacher's desk and the chalkboard.

In some lessons, however, as Monadescribed, and as I observed, she reorganized the arrangement of the desks so that they would be convenient for cooperative learning. She put desks into pairs facing each other. Teacher Mona also said, "I would like to have tables for the students instead of desks".

Mona was teaching a class of about 40-55 students. She found that class size was a constraint on the interaction between the students with each other or with her. She said "How can I do a lesson about STS with so many students? …I do not have the time for them or to meet their needs; however, I try to do my best within the limited time and resources."

- School context

Mona, like the other ten participants in the study, was in a traditional context. The school context indicated a traditional philosophy of teaching and learning, not just for science but for all subjects. The main interest of the school administration was the examination results. The school's rules and circumstances created a socio-cultural atmosphere that had a great influence on teaching practices, to the extent of making it very difficult for Monato be as creative as she would have liked: "I can't do what I want to do; I feel that I am restricted". Like other teachers, she was forced to cover all the topics of the science curriculum over a specified period of time, training the students so that they would do well in the monthly, half-termly or final exams. "I have to stop teaching every four weeks and try to do revision so the students will be confident and pass the monthly exam; otherwise I'll get into trouble with everyone – the school administration, students and parents." However, she had a good social relationship with her colleagues, saying; "my colleagues are very cooperative and supportive". They let her change the timetabling with them to allow her extra time so she could teach using a cooperative learning approach.

- Student context

Mona's views of students' interests, needs, attitudes, etc., influenced her interactions with them. She said:

The students only pay attention when they recognize that there is a formal way of presenting the subject that they interpret as necessary to help them pass the exams. ... When we begin with students' background knowledge, students will be more involved and aware of the problem. And when we give students new information, they will receive it with pleasure. …Today's student deals with various technologies like the computer, the internet, TV, satellite, etc… I do my best to cope with the developments of the modern age.

- Personal context

Mona had grown up in a family that was interested in taking her to museums and to zoos. These early experiences with science had made her love learning science on her own and teaching science as she learnt it. As a mother herself, she treated students as her children. "*Having children also affected my teaching as I began to treat students as if I were their mother. I began to concentrate on understanding the students, identifying their needs and relating science to their real lives."*

Teacher Mona's religious beliefs had influenced her professional beliefs and practices. She said:

I do not recommend the use of the internet because we are Muslims and have special opinions concerning controversial issues. When students surf the internet, they may come in contact with people from other religions. The student at this age cannot discriminate between what's good and what's bad. …I start with the students' opinions and after this I present my opinion. I'll present my opinion from a religious perspective because we're an Islamic society.

The epistemology of science

Mona believed that science was a constructed knowledge and that this knowledge differed in its meaning from one individual to another: *"A science teacher should help students to construct their knowledge about* *the STS issues by themselves. The teacher can guide the students to learning resources. The teacher should also make students aware of their experience with STS issues."* In practice, Mona used cooperative learning as a strategy to help students to work together and help each other to construct the knowledge together, also she encouraged students to use their experiences related to the STS issues that they were discussing.

In the interview, she emphasized the importance of activating students' background knowledge as it facilitated their understanding of the STS issues. She also confirmed the importance of identifying students' previous experience as this enabled the teacher to assess the level of their understanding of the STS issue and their beliefs about it. She also emphasized that identifying students' previous real-world experiences with STS issues enabled the teacher to recognize students' misconceptions and negative attitudes toward the issues, which was important for helping them to form positive attitudes towards learning science and learning about the STS issues related to their own life.

Learning science through STS In the interviews, it was evident that teacher Mona held constructivist beliefs about learning science through STS. She emphasized that it would be more powerful for the students to discover the interactive relationship between science, technology and society for themselves, instead of her simply telling them how science, technology and society interacted: *"From my own experience, I realized that if I help the students to engage indifferent activities for a while in a positive manner and in a directed way, they would easily understand the relationship amongst science, technology and society by themselves."*

She tried to make students feel more comfortable by creating a collaborative and non-threatening environment in which they built on each other's' ideas and took risks. She used cooperative learning extensively, defining it as "*students working together towards a common goal where all members have to contribute".* From her teaching experience, Mona had formed beliefs about learning: "*I noticed that students often have problems learning and believe that they cannot learn effectively unless steps are taken by someone else to address this. My own belief is that students should learn to solve problems independently from their teachers and with the support of their peers, because adults will not always be available to help them."* In the interviews, Mona highlighted the importance of creating a sociable atmosphere with the students for discussing STS issues. *"One of the most important things I like to do in my classes is to build a family atmosphere ...I feel that I am like their mother, and they are like my children. I try to make them aware of this, so they can feel free in their discussions. When we discuss the STS issues in groups, my students should feel supported by me and each other especially when they're doing their best."*

In the class and before she started the lesson, teacher Mona would remind her students about this family atmosphere: "*We all work together to achieve the main aim of understanding the subject we're studying and that requires us to help and cooperate with each other".* Indeed, her beliefs seemed very much in line with her practices. Her classroom atmosphere seemed informal, and most of the time one could see and hear the students laughing and talking to each other. In practice, she let all the students in the class sit with each other at various times. She encouraged this by randomly selecting seating arrangements, and organising groups from which students selected others with whom they wanted to work. Through such approaches as role-play and student modelling, she taught them cooperative skills to help them work with others more effectively.

Teaching science through STS

Mona combined such teaching methods as enquiry, problem-solving and cooperative learning. Her varying of teaching methods depended on the nature of the lesson topic. Her practice conformed to the belief she expressed in the pre-interview, *"No one specific teaching method can be used to achieve the aims of science education in general, or the STS lessons in particular".* She relied more on group work: "*My integrated class is strictly organised in cooperative groups, not every day but most days."* She strongly supported cooperative learning, stating that, *"I think it works better especially when you teach subjects that relate with society*", and gave some reasons for preferring cooperative learning: *"When students work with each other in groups, I move between the groups and I watch what they are doing, how they understand, discuss, negotiate, argue…I have more contact with them."* Through cooperative learning, Mona tried to develop the students' sense of responsibility by asking them about the results of their work and their role in successfully concluding the group's task. She encouraged cooperation within each group and competition among groups.

Asked about her strategy in selecting and distributing students in cooperative groups, Mona replied that she selected them on the basis of their abilities, putting students with different cognitive and social abilities in the groups. Such a distribution helped her to meet the individual differences among students since brilliant students would help weaker students. Students also learned social behaviour from each other. Her main role while the students were carrying out activities and during discussions was to see that all the students were involved. She made sure that no individual student dominated the discussion in his group.

In her classes, Mona tried to make students more involved in STS learning and more animated in their discussions about the issues. During discussion with Mona about her use of cooperative learning she said, "*Cooperative learning develops social skills in the students by giving them the chance to discuss with each other and with the teacher. It also improves self-image by making the student aware of his ability to participate, understand and interact socially."* Like the other participant teachers, Mona adhered to the content of the textbook. So if the lesson did not tackle the relationship between science, technology and society, she did not refer to this relationship. She explained this by saying,

Don't forget the exam and the supervision. Supervisors inspect to see whether or not the teacher adheres to the curriculum to achieve the aims set by the Ministry. Second, the exam affects the way one teaches to a great extent. Furthermore, the teacher needs preparations to be able to reorganize the curriculum in the light of the STS.

Although the pressure of the exams on teacher Mona's practices in the classroom, she created a learning environment that motivated students to think collaboratively and critically about scientific issues related to their daily experiences. In the interview, Mona said "*I try to understand the student's current thinking about STS topic under discussion ... I try to create non-judgemental climate." For example, she encouraged the students' curiosity by using open-ended questions*. In the topic about "electricity", she asked the following questions:

- Do any of you have a torch battery? Have you ever thought of the way it works to give us light?
- How does the electric current reach our houses?

Asked in the post-interviews about the aims behind her questions, she said;

I believe that evaluation is not intended to make judgments about the students' achievements. Instead of that, evaluation should be used as a tool to enhance both the students' learning about STS issues and my understanding of how the students understand these issues, so I can help them more.

The questions asked by Mona were open-ended in nature and did not require specific answers. At the same time, she used traditional evaluation that focused on assessment of the cognitive aims included in the lesson plan. However, she kept encouraging the students to think creatively using open-ended questions such as:

- Under what conditions can air pressure increase?
- How can you make this experiment or device better?
- What's your opinion of…?
- What's your evidence for…?
- What would be the result of this experiment if you used more or less substances?

Like other participants in this study who helped and trained the students to pass the exames, Mona often reminded students of the exams and how to answer questions. She used to give models of answers to the exam questions. In this respect, her practices were mismatched with her constructivist belief that stressed the importance of students' scores to trace their learning progress. She said, The main criterion against which I'm evaluated as a teacher is the percentage of the students who succeed. I don't prepare exams myself. So I have to train the students to deal with the exam as it is. The end-of-month and end-of-year exams are mainly directed towards evaluating my teaching.

Figure 2. **A model of the relationships between science teacher beliefs and teaching practices**

Discussion

In analysing the findings, four main themes emerged. These can be summarised as:

- The degree of consistency or inconsistency between teachers' beliefs and practices.
- The importance of epistemological beliefs in shaping and reshaping teachers' beliefs and practices.
- The influence of social-cultural contexts on the relationship between beliefs and practices.
- A variety of mediating factors influence the degree to which teachers are able to put their beliefs into practice.

Figure 2 shows the relationship between the four themes. The following paragraphs discuss these themes with the literature review.

The degree of consistency or inconsistency between teachers' beliefs and practices

This study shows consistency between science teachers' traditional pedagogical beliefs and their practices but there was inconsistency between some teachers' constructivist beliefs and their practices in most cases. The results are in line with the results of several researchers (e.g. Ogan-Bekiroglu & Akkoç, 2009) that beliefs interact with practices in complex ways. What teachers profess to believe and what they actually do in the classroom may or may not be consistent. The complexities of classroom life can cause conflict and constrain teachers' abilities to stay faithful to their beliefs and provide instruction which aligns with their theoretical beliefs (Fang, 1996).

The findings of the study indicated that the teachers who held mixed beliefs were student-centred in how they viewed themselves as teachers, but were teacher-centred in their classroom actions, and did not realise or reconcile this inconsistency. The inconsistency between their belief about student-centred teaching and their actual practice can be interpreted as these teachers having adapted to their educational environments, they constructed sub-universes organized from the perspective of the teacher as self in-relation-to the social context; where a universe is defined as "the knowledge and beliefs constructed by a teacher" (Simmons et al, 1999 p. 948). Individual teachers construct their own sub-universes within each of the social contexts in which they work.

In comparing the findings of this study to similar studies carried out in other countries, the first difference concerns the nature of the relationship between teachers' beliefs and practices. Goelz (2004) found that teachers' beliefs and practices were more consistent with the social constructivist theory of learning. The situation appeared to be different in Egypt, where constructivist beliefs and classroom practices were more consistent with a Piagetian constructivist theory. Even though there were some attempts by teacher Mona to implement the principles of social constructivist theory by using cooperative learning, the classroom environment and the activities organized by teachers Zaynab, Farida, Ahmad, and Mona were clearly cognitively oriented, and there was comparatively less concern for the development of the social skills of the students as citizens. In addition, there was an evident conflict in the consistency of implementing the constructivist theory. While teachers' beliefs appeared to be consistent with constructivist theory (student-centred, students' experiences, students as active participants, etc.), their classroom practices were mainly teacher-centred.

In the three case studies Farida, Zaynab and Mona, the data analysis shows a number of beliefs about teaching and learning that together reflect a philosophy which is compatible with constructivist learning theory. However, the classroom observations for these cases show that a teaching practice based totally on such beliefs is anything but easy to accomplish. Even when teachers have constructivist beliefs, limitations coming from (a) the strain of being responsible for a large size of class, (b) following the textbooks, (c) the examination system, or (d) external pressures on what they must do in the classroom - all of these factors interfere with the implementation of a constructivist philosophy. What was implemented were the traditional practices, based on what is relatively easy to implement and what draws less interference from competing forces; this often bears only a superficial resemblance to the philosophy that a teacher may espouse.

Epistemological beliefs and pedagogical beliefs and practices

The findings of this study about teachers' epistemological beliefs support a possible relationship between teachers' pedagogical beliefs and classroom practices. The results are in agreement with those of other studies that investigated the influence of epistemological beliefs in teaching (Benson, 1989; Gallagher, 1991). This finding concurs with Hashweh's (1996) study that teachers' professed epistemological beliefs - view of knowledge and view of learning - were consistent with their preferred ways of teaching. Several studies describe how teachers' epistemological beliefs influence their instructional methods as well as the degree of consistency among teachers' professed epistemological beliefs and their actual practices in the classroom (Schoenfeld, 2002; Tsai, 2002; Tobin, 1994). Kang and Wallace (2005) found that teachers' epistemological beliefs were closely connected to their pedagogical approaches to achieving different teaching goals.

Contextual factors impacting on teachers' beliefs and practices

The analysis of data found, as shown in Figure 2, that teachers tended to use the history of their own schooling and, in particular, specific teacher role models to guide their own practices. Albert Bandura believed that behaviour such as traditional teaching or constructivist teaching was learned through a process called observational learning, which allows one to develop an idea of how a new behaviour is formed without actually performing the behaviour oneself. This information can then be coded (into symbols) and used as a guide for future action. This explained exactly how teachers' experiences of university teacher education, of life-in-school experiences, of past school experiences, of life-out-of-school experiences, of personal religious beliefs, and of experience from training abroad formed teachers' beliefs which, in some cases, turned into practice, or at least into teachers' intention to practise. Maslovaty (2000) noted that a teacher's belief system, crystallised through a cultural context, resulted in the development of different educational ideologies. Maslovaty also found that teachers' social value orientation contributed to the choice of strategy to cope with socio-moral dilemmas. However, transforming teachers' plans for actions into real practice in the classroom depended on other contextual factors, e.g., constraints, school environment, teachers' personal religious beliefs, and their experiences. That conclusion is supported by Schoenfeld (1998) who claimed that teachers' beliefs shaped what they perceived in any set of circumstances; what they considered to be possible or appropriate in those circumstances; the goal they might establish in those circumstances; and the knowledge they might bring to bear on them.

The findings as shown in Figure 1 indicated that there was a higher degree of consistency between traditional beliefs and traditional practices than between constructivist beliefs and constructivist practices. This dissimilarity in the degree of consistency can be explained by the strong influence of the educational-contextual levels, which included an educational management context level, workplace-school contextual level, and classroom contextual level. Also, the findings of the study agree with the argument of Hargreaves (1994) about the powerful influence of the educational social-cultural context, not just in the daily life of a teacher, but as a vital context for professional development. According to Hargreaves:

What they do there in terms of classroom styles and strategies is powerfully affected by the outlooks and orientations of the colleagues with whom they work now and have worked in the past. In this respect, teacher cultures, the relationships between teachers and their colleagues, are among the most educationally *significant aspects of teachers' lives and work. They provide a vital context for teacher development and for the ways that teachers teach*. (1994: 165).

In this sense, the Egyptian educational system inclines towards a high degree of consistency between teachers' traditional beliefs and their traditional practice. For instance, the teachers were governed by the textbooks, more than by any sense of what the learners might already know, or need to know beyond the formal examinations. In this sense, textbooks with a traditional type of content and use appear not to be suited for constructivist science instruction. Textbooks are usually written in a limited, authorial style and they provide limited empiricist views of the nature of science (Duit, 1996). Therefore, the study does not argue against the textbook but it argues for constructivist textbooks that provide information to the students in an efficient way (Guzetti and Glass, 1992) and students' conceptions are explicitly addressed as often as possible in different ways (Duit, Häußler, Lauterbach, & Westphal, 1992).

Teachers Zaynab, Ahmad and Farida offered a notable example of the relationship between teachers' beliefs and practices. All of these teachers were categorized under mixed beliefs but according to their practices. Farida was categorized under traditional practices and teacher Zaynab was categorized under mixed practices. This may be because the negative environment or social context pressures did not provide solid support or congruence with the constructivist beliefs that teachers Ahmad and Farida held and the "framework of action" that these teachers already had. Conversely, a partially positive school environment into which teachers Zaynab and Mona were put reinforced some of their constructivist practices. The school environment supported the strength of the teacher role identity so that classroom practices were enhanced or improved (Knowles, 1992). In this way the constraints or social context element of the teaching environment were significantly influential. This conclusion was supported by Talbert and McLaughlin (1993) who defined the "context effect" as a notion implying that conditions such as policies, resources, curricula, goals, values, norms, routines and social relations in the school influenced teaching and learning outcomes. For example, in teacher Mona's case, she faced a lot of problems in teaching STS issues through cooperative learning, in terms of resources, time, examination, content etc., but to some extent the administrative system, and especially her colleagues, offered a flexible environment. She was given extra periods to teach according to that teaching method and sometimes colleagues exchanged their classes with her so that she could have two consecutive periods (110 minutes in total) with one class. Thus, teachers with strong positive teacher role identities are better able to deal with the disruptive constraints that teachers have to face.

Barriers as mediating factors between beliefs and practices

As the analysis indicated, constraints acted as pointers directing teachers' beliefs and practices and delimiting their attempts to enact their beliefs in practice. These findings agree with other studies (Muskin, 1990; Simmons, 1999; Goelz, 2004) that there is a mismatch between the beliefs and practices of many teachers. Goelz (2004) discovered that six out of seven young social studies teachers consistently managed to teach using methods that reflected their educational beliefs. In contrast to Goelz's results (which showed that the six teachers who consistently practised their education beliefs identified themselves as having either non-traditional or mixed beliefs), the findings of the current study revealed that seven of the ten teachers surveyed practised their educational beliefs about STS, of whom six had traditional beliefs and one held mixed beliefs. Similarly, Ajzen (2002) suggests there are several elements between beliefs and practices that cause beliefs and practices to be mismatched. However, many studies argue that beliefs and practices are highly inconsistent. Real-life factors such as learner behaviours, time, resources, and course content have an impact on the degree of belief-practice consistency (Johnson, 1992; Bennett et al, 1997). Fang (1996) also argues that contextual factors can have powerful influences on teachers' beliefs and, in effect, affect their classroom practice.

The data analysis showed that there was interaction both within and between the external and internal constraints which enlarged the degree of influence of these constraints. For example, the lack of equipment was related to large class sizes, which in turn influenced the time available for teaching/learning. The study's findings indicated that constraints appeared to be cyclical, as well as multifaceted and nested. All these constraints acted to encourage teachers to conduct classes in less flexible ways and to display a firm stance toward the students. Over time, these constraints, or the teacher's reactions/coping behaviour towards them, may evolve into a set of beliefs that will gradually cohere into a personal philosophy of teaching.

Analysis of the data demonstrated, as shown in Figure 2, that the social context or the environment surrounding teachers affected the degree of influence of the mediating factors on their beliefs and practices. The degree of the influence of these constraints depends on the interaction between teachers, behaviour, beliefs and environment. In this process, teacher beliefs are developed and modified by social influences and physical structures within the environment. In line with Giddens's structuration theory, the interpretation of the data showed that all the various forms of constraints were, in varying ways, also forms of enablement. They served to open up certain possibilities of action at the same time as they restricted or denied others (Giddens, 1984). Constraints enable traditional practices and restrict the constructivist practices. The findings of the study also agreed with Giddens's conception of structure and agency, i.e., that the range of free action which agents (teachers) have is restricted by external forces (e.g. the examination system, lack of time, work overload, high density in the classroom, lack of STS resources or materials, the course content, etc.) that set strict limits on what these teachers can achieve. For structuralists, human actions are largely determined by the social structures that people inhabit (Hodkinson, 2004). Similarly, Dirkx, Kushner and Slusarski (2000) argue that the social structures in which teachers work profoundly shape their choices.

Implications

The study showed that teachers reflected both traditional and constructivist theories of learning and teaching science through STS. The comparison between each of the teachers' beliefs and practices also revealed that, generally speaking, the teachers' observed practices were more traditional than their expressed beliefs. There may be two reasons for this: first, the teachers may have believed that it was necessary to reform science education and that they should have constructivist beliefs in the form of intentions (Fishbein & Ajzen; 1975). Secondly these beliefs were actually ones that teachers held consciously or unconsciously (by 'unconsciously', I mean that a teacher was unaware of those beliefs until he/she was asked about them in the research). This implies that the role of science education is not simply to suggest new theories or teaching techniques, but that teacher educators need to allow teachers to explore and express their existing beliefs and try to assimilate new ideas by re-forming their beliefs or constructing new ones. Teachers must be helped to make their own construction of the world explicit.

As discussed above, not all teachers' beliefs turned into practices. From the teachers' viewpoints, there were many factors that acted as barriers to teachers putting their beliefs and frameworks for action into practice. These barriers were identified, as was the mismatch between the teachers' expressed beliefs and their observed practices. Teachers' beliefs were mainly influenced by types of constraints which Ajzen (1985, 2002), in his "theory of planned behaviour", called "perceived behavioural control" or "perceived control over the performance of behaviour". Therefore, to enable teachers to attempt to resolve inconsistencies between their beliefs and practices, science teacher educators should help teachers to find ways of thinking creatively about these constraints and to use coping strategies with such constraints. Implications for teacher education include the need for addressing ways to deal with teaching constraints for constructivist teaching approaches (Kang, 2008). Possible ways to do this include changing the emphasis of the educational system from an examination-orientation (Hargreaves, 1994) to a learning–orientation.

Although constructivist theory is attractive when the issue of learning is considered, deep-rooted problems arise when attempts are made to apply it to instruction. As reported in this study, most of the problems associated with implementing a constructivist approach to teaching could be overcome if teachers were willing to rethink not only what it means to know subject matter, but also what it takes to foster this sort of understanding in students (Prawat, 1992). This awareness could be developed as part of continuing professional development for teachers.

The study may draw the attention of decision makers and curriculum developers to the fact that teachers do not passively accept innovative ideas once they have been informed about them, unless they are convinced of their effectiveness. In this respect, Yager (1991: 91) maintains that the central failure of any “fundamental reform” in science education is primarily the responsibility of teachers “because they are major forces for maintaining the status quo in the curriculum”. In this respect, Vulliamy et al. (1997) argue that curriculum changes are rarely implemented as originally intended but instead undergo a process of “mutual adaptation”.

Research reported that if science teachers’ existing belief structures are incongruent with the underlying philosophy of the intended curriculum, e.g. STS, they will hinder the successful implementation of that curriculum (Author, 2010). So if the education authorities fully support the change in philosophy to a constructivist view of science teaching and learning, it is recommended from the findings of this study that new innovative professional development programmes based on a constructivist philosophy should be provided for all science teachers.

Teacher beliefs matter, and identifying, discussing, and reflecting upon the belief–practice relationship should be a component of every teacher education programme and teacher professional development activity (Haney et al., 2002). Thus, when considering the STS approach to science education, teachers’ beliefs about STS implementation require attention (Carroll, 1999), without which, negative beliefs concerning STS implementation and enquiry-led learning could defeat the reform movements emphasizing STS.

This study suggests that when we plan a teacher professional development programme, this should be developed based on an in-depth understanding of the aspects of consistency and inconsistency between teachers’ beliefs and practices. This will help contextualise and personalise the teacher training activities to meet the teachers’ needs but will also consider the institutional contexts that the teachers are working in. In addition, when developing the teacher training programmes, teachers should be made aware of the conflict and inconsistency between their beliefs and practices. They should be encouraged to practise reflective thinking to help them resolve the problems of their teaching in practice (Dewey, 1933). Richardson (1996) found that reflecting on one’s practice directly influenced beliefs and practices and moved teachers towards more constructivist approaches. The recommendations set out in the National Science Education Standards

(National Research Council, 1996) acknowledge the central role of the teacher in the reform of science education. The Standards recognize the implicit and explicit beliefs that teachers have about science and the teaching and learning of science, and they advocate opportunities for teachers to examine their own beliefs when learning to teach science.

Conclusion

This paper has attempted to show how science teachers implement their beliefs into practices in the classroom to enact STS issues. Also, this paper showed three main patterns of beliefs, which are traditional, mixed, and constructivist and three main patterns of practices which are also traditional, mixed, and constructivist. Also, it showed that four major types of beliefs and practice relationships emerged: teachers with traditional beliefs have a high consistency with teaching using traditional practices; the majority of teachers with mixed beliefs (traditional-constructivist) have traditional practices; one teacher who has mixed beliefs has mixed practices; and with the only teacher (Mona) who held mainly constructivist beliefs some of her practices were inconsistent with her beliefs. In addition, the data analysis showed a number of striking similarities in the four case studies' beliefs and practices. However, there were also a number of differences. Finally, this paper showed that there is some consistency and also some inconsistency between teachers' beliefs and their practice. The paper argued that when applying the constructivist perspectives in school science education, the social contexts of the school and science classroom in which teaching and learning are happening have to be considered and negotiated by all parties and learning communities.

Case studies of the teachers who enacted the constructivist perspectives in their classroom showed that they used differing teaching approaches to engage their students in learning science and to make them active learners. These cases show that in a rigid sense, there is no constructivist learning. Learning, whenever it happens (and it happens also, even successfully, in more traditionally oriented approaches) is viewed as active construction by the learner. In that more rigid sense the constructivist view does not favour any particular approach to learning science. But the idea inherent in constructivism of taking the students' beliefs and conceptions seriously has led to developments towards making the constructivist view a genuine part of attempts towards a student-centred pedagogy of science instruction. For these attempts to continue successfully as part of the teachers' and learners' practices in the classroom, contextual factors need to be considered and dealt with.

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