
# Science-Technology- Society (STS): A new paradigm in Science Education

**Nasser Mansour***

University of Exeter, United Kingdom and Tanta University, Faculty of Education, Egypt

Mansour, N. (2009). Science-Technology- Society (STS): A new paradigm in Science Education. *Bulletin of science, technology and society. 29*(4), 287-297. DOI: 10.1177/0270467609336307

## Abstract

Changes of the last two decades in goals for science education in schools have induced new orientations in science education worldwide. One of the emerging complementary approaches was the science-technology-society (STS) movement. STS has been called the current mega-trend in science education. Others have called it a paradigm shift for the field of science education. The success of science education reform depends on the teachers' ability to integrate the philosophy and practices of

* Mailing address 1: Faculty of Education, Tanta University, El-Giesh Street, Tanta, Gharbia, Egypt. Mailing address 2: School of Education and Lifelong Learning, University of Exeter, Heavitree Road, Exeter, EX1 2LU, UK.
E-mail: mansournasser@hotmail.com / telephone: 0044(0)7979438868

current programmes of science education reform with their existing philosophy. Thus, when considering the STS approach to science education, teacher beliefs about STS implementation require attention. Without this attention, negative beliefs concerning STS implementation and inquiry learning could defeat the reform movements emphasizing STS. This paper argues the role of STS in science education and the importance of considering science teachers' beliefs about STS in implementing significant reforms in science education.

***Key words***: Science-Technology-Society (STS); Science teachers' beliefs; STS aims.

## What is STS?

Science, Technology and Society STS is an interdisciplinary field of study that seeks to explore and understand the many ways that modern science and technology shape modern culture, values, and institutions on the one hand, and on the other how modern values shape science and technology. Ziman (1980) identified STS as a kind of curriculum approach designed to make traditional concepts and processes found in typical science and social studies programmes more appropriate and relevant to the lives of students. According to Yager (1990), STS may be defined as an integrated approach to science teaching, while Wraga and Hlebowitsh (1991) have defined STS as a topical curriculum that addresses a broad range of environmental, industrial, technological, social and political problems. According to Heath (1992), STS can be referred to as an instructional approach that incorporates appropriate STS knowledge, skills, attitudes, and values.

Hofestein et al. (1988) define STS as teaching science content in the authentic context of its technological and social milieu, while the NSTA views STS as the teaching and learning of science in the context of human experience. It also means determining and experiencing ways that basic science and technology concepts and processes are handled in society. In other words, it means starting from the real-world problems included in the students' perspectives, instead of starting with the basic concepts and processes (NSTA, 1990). According to Yager, STS means "dealing with students in their own environments and with their own frames of reference" (1996: 10).

Therefore it means starting with students and their questions, using all resources available to work for problem resolution, and advancing to take actual actions individually and in groups to resolve actual issues.

## STS as a paradigm shift on science education

Based on the view of science as knowledge and the traditional educational view of cognitive learning, science education focused for a long time on imparting knowledge in the different branches of science. Teachers continued to use teaching methods that involved the memorizing by students of the largest amount of knowledge, and the science curricula continued to view the human cognitive heritage as the aim that should be adhered to. This traditional paradigm of the science curriculum began to take shape in the nineteenth century, and its form was highly influenced by the social and political realities of that time (Kliebard, 1979). This social and political influence on the institution of science had, in turn, a dramatic effect on the structure of our present-day science curriculum.

In addition, the traditional paradigm of science education is characterised by the professionalisation of science. School science has been a collection of specific disciplines, such as astronomy, biology, chemistry, geology, physics (Yager, 1996; Aikenhead, 1994). In this respect, Blades (1997) further describes how the revamping of the science curriculum was influenced by the “structure of the discipline” movement. From the perspective of curriculum theorists, the rationale of this movement was to have subject specialists creating curricula. Furthermore, the best method to encourage students’ interest in a particular subject such as science was to “...render it worth knowing, which means to make the knowledge gained usable in one’s thinking beyond the situation in which the learning has occurred” (Bruner, 1960: 31).

With the famous space technology revolution embodied by Sputnik in Russia in 1957, a similar revolution began to occur in school curricula, as educationists started to criticize the science and mathematics curricula. Blades (1997) described how, within the United States, this scientific feat in space technology created a national fear of the

Soviets and a perceived crisis in education. One of the results of the crisis was the effort to revamp the science curricula in the US and the UK, which in turn influenced science curricula throughout the entire world. Following the Soviet launch of Sputnik, as Yager (1996) points out, even though the artificial satellite was more of a technological than a science achievement, attention and funding were directed toward reform that illustrated and emphasized basic science.

American educators demanded curricula that could help Americans achieve excellence. Therefore, viewing science as inquiry was central to most of the major curricula of the 1960s (Welch, 1981). This movement was rich in new ideas and in views of science and mathematics curricula. Thus, the aims of science education were changed from emphasizing cognition to ways of acquiring and developing knowledge. Accordingly, the roles of the teacher and the learner changed. The teacher was no longer seen as a store of knowledge and by the same token the student was no longer seen as a passive recipient of knowledge. The main role of the teacher changed and became the designing of students' thinking and activities, while the role of the student became the active search for knowledge. This was the so-called 'discovery' or 'inquiry' trend (Schwab, 1966), which called for developing science curricula that could make the students into young scientists who practiced science processes like old scientists. According to this, students performed the activities of identifying problems, collecting data, setting hypotheses, designing experiments, experimenting, deducing, generalizing, and other mental and experimental skills (Carin & Sund, 1989).

With this new trend, too, it was expected that learners would develop the skills of observation, classification, measurement, communication, prediction, deduction, identifying problems, setting hypothesis, designing research plans, and organizing and analyzing. It was also expected that they would develop positive scientific qualities such as curiosity, objectivity and deliberate judgments (Carin & Sund, 1989). However, this emphasis did not affect teaching practice in any appreciable way (Welch, 1981).

Schools in American and in other countries around the world continued for a long time to use curricula built in the light of the inquiry approach. Yet the outcomes of such education disappointed the educationists and did not seem worthy of the efforts that had been exerted for a decade or more to build the curricula (Yager & Tamir, 1993). In this respect, Yager and Tamir maintained that those process-centred curricula did not lead to the desired effects on teaching. It seems, therefore, that teachers were also to blame for the failure of the inquiry trend.

Specialists confirmed that despite the great efforts exerted to build curricula based on the inquiry approach, the classrooms remained the same as they had been before the inquiry trend. Emphasis continued to be placed on memorization and performing experiments that proved previously-taught facts. Thus, many students, especially adolescents, began to turn away from education (Yager & Tamir 1993: 638). Yager and Tamir also noted that the 1960s curricula were based on an assumption that there was a pattern of discipline, which would make the learners acquire scientific inquiry skills as well as knowledge. It was also assumed that the learners would employ knowledge and skills in the future and that they would apply what they had learnt in solving the problems that faced them in their everyday life. This would require continuous deduction and positive attitudes towards science and inquiry.

After the Second World War and the dropping of the nuclear bombs on Nagasaki and Hiroshima in Japan in 1945 that killed more than 150,000 individuals, the negative effects of science and its applications began to be evident. At that time, scientists called for directing science and technology towards the welfare of mankind rather than to its destruction. From that time on, organizations and societies concerned with the wise use of science and technology began to be set up, including for example, the Society for Social Responsibility in Science (SSRS), the Scientists and Engineers for Social and Political Action (SESPA), the British Society for Social Responsibility in Science (BSSRS), United Scientists for Environmental Responsibility and Protection (USERP), and the Society for Social Responsibility in Engineering (SSRE).

These organizations and societies aimed to alert scientists of the social role of science and their social responsibility. More and more organizations seeking to humanize science began to come into being. Such organizations began to shed light on the destructive effects of science and technology on the environment, which began to suffer severely as a result of science and technology (Solomon, 1993; Yager, 1996, Martin & Beder, 1993). Furthermore, many publications tackling the social problems of science and technology appeared, like Rachel Carson's Silent Spring in 1962, Barry Commoner's Science and Survival in 1967, Paul Ehrlich's The Population Bomb in 1968, and Barry Commoner's The Closing Circle; Nature, Man and Technology in 1971. Those publications sought to spread environmental awareness among citizens of the international society, with the intention that they wuld protect the environment (Solomon, 1993).

In the early 1970s, educational experts observed that science and technology led to many passive social, economic and environmental changes. They therefore called for science programmes that related science, technology and society to make students aware of the importance of the effects of science and technology on their lives (Agin, 1974). Ziman called for teaching science to students in all grades according to the interaction between science, technology and society, while in the 1980s the American National Science Teachers Association (NSTA) considered the interaction between science, technology and society to be the basis of science education, since it emphasized the importance of scientific and technological education and teaching the interactive relationship between science, technology and society (NSTA, 1982).

It was suggested in the Keil discussions at the Fourth International Symposium on World Trends in Science and Technology Education in August 1987, that STS programmes had the greatest potential for enabling students to attain the goal cluster of Project Synthesis (Hofestein, et al, 1988). Project Synthesis, a comprehensive research project conducted in the USA, considered four goal clusters (Kahl & Harms, 1981):

Personal needs: science education should prepare individuals to utilise science for improving their own lives and for coping with an increasingly technological world.

Societal issues: science education should produce informed citizens prepared to bear responsibility with science-related societal issues.

Career awareness: science education should give all students an awareness of the nature and scope of a wide variety of science-related careers open to students of varying aptitudes and interests.

Academic preparation: science education should allow students who were likely to pursue science academically as well as professionally, to acquire the academic knowledge appropriate to their needs.

In one sense STS efforts are seen as responses to the first three goal clusters of Project Synthesis. STS means focusing on the personal needs of students, i.e., science concepts and process skills that are useful in the daily lives of students. It focuses on societal issues, i.e., issues and problems in homes, schools, and communities, as well as on the global problems that concern all humankind. STS also means focusing on the occupations and careers that are known today (Yager, 1996:7).

Solomon (1993) mentioned another push towards a new kind of science education that came indirectly from an influential report by a group of the world's top intellectuals, economists and businessmen in the Club of Rome. The report on The Limits to Growth quoted a debate that included items such as the exponential growth in fuel use, and the finite nature of the fossil fuel reserve, the world population explosion and its limited production of food.

## STS and aims of science education

A major goal of education is, or should be, to improve the quality of human existence. An essential part of this goal is the promotion of rational ways in which citizens can influence the conduct and direction of human affairs and can live in a democratic society (Longbottom & Butler, 1999; Quicke, 2001). In democratic societies, the quality of the decision made by the laity is of fundamental importance. Lay people's abilities to promote their point of view on socio-scientific issues are therefore significant. In this respect, Longbottom & Butler (1999) argue that these assumptions link education in general and science education in particular. Quicke (2001) argues that the primary justification for teaching science to all children is that it should make a significant contribution to the advancement of a truly democratic society. In other words, the changes in current society lead to changes in the role of education in general, and in science education in particular.

Science education is the production of citizens who are creative, critical, analytical, and rational. For this reason, science for citizenship has been discussed as an important goal of science education (Kolstoe, 2001). In this respect, Longbottom and Butler (1999) refer to science education that should be designed for the general population rather than for a specialist group of future scientists, and that should lead to empowerment in some general sense of giving citizens more control or decision-making ability. To do this, Price and Cross (1999) refer to science education should give pupils a basis for understanding and for coping with their lives. They should be given applications and effects of science in their personal and social life.

The National Science Foundation (NSF) Advisory Committee for Science Education recommended that the traditional approach to science education in science be rethought with more 'emphasis on the understanding of science and technology by those who are not and do not expect to be professional scientists and technologists' (Hurd, 1998). The implication is that notions of scientific literacy should be embedded in contexts that promote a socially responsible and competent citizen (Hurd, 1998). For Jenkins (1999) citizens need to be 'scientifically literate' in order to be able to contribute to decision-making about issues that have a scientific dimension, whether these issues are personal (e.g. relating to medication or diet) or more broadly political (e.g. relating to nuclear power, ozone depletion or DNA technologies).

Science for citizenship is an important educational goal (Jenkins, 1999; Duggan & Gott, 2002; Hurd, 1998; Longbottom & Butler, 1999; Kolstoe, 2001). This is a challenge for school science education. Therefore, this raises questions regarding how science education can prepare students as citizens.

As future citizens, students have the enormous responsibility of making decisions that require an understanding of the interaction of science and technology and its interface with society. The Science-Technology-Society (STS) movement has been strongly identified with meeting this goal but despite its benefits, putting theory into practice has, so far been difficult (Mansour; 2007).

In response to the pressing needs of modern societies, it has been argued that science education should pay more attention to the science, technology and society (STS) interface (Eijkelhof & Lijnse, 1988). In all science programmes that have been identified as ‘exemplary’ in the National Science Teachers Association (NSTA) ‘search for Excellence programme’, there was an overt effort by science teachers to help students develop into scientifically literate citizens. One of these programmes accepted by NSTA was the Project Synthesis (Ost & Yager, 1993). Scholars have argued that inclusion of socio-scientific issues through the Science, Technology, and Society (STS) movement in the science curriculum will help in developing the scientifically literate citizen (Kolsto, 2001; Dimopoulos & Koulaidis, 2003; Wiesenmayer & Rubba, 1999; Bybee, 1987; Hart & Robottom, 1990; Yager, 1993; Ramsey, 1993). Moreover, NSTA refers to STS issues as the best way of preparing young people for citizenship. This is clear in NSTA’s definition of STS:

> “Basic to STS efforts is the production of an informed citizenry capable of making crucial decisions about current problems and taking personal actions as a result of these decisions. STS means focusing upon current issues and attempts at their resolution as the best way of preparing people for current and future citizenship roles” (cited from: Ost & Yager, 1993, 282).

The primary objective of an STS education is to present contextual understanding of current science and technology and provide students with the intellectual foundations for responsible citizenship (Waks, 1987). In their study, Ramsey & Hungerford (1989) and Wiesenmayer & Rubba (1999) showed that an STS issue investigation with an action instructional model that addresses each of the four STS goal levels is crucial in promoting citizenship actions on STS issues. Within STS in science education, the emphasis on the interconnections between science and society has entailed a focus on science-related social issues. It has been argued that to empower the students as citizens, there is a need to emphasise STS (Kolstoe, 2001). It is clear that the science education community values the inclusion of a STS approach in science education programmes. Therefore, it is worth to raising question: what are science teachers’ beliefs concerning the STS issues? This is what the next section will focus on.

## STS and Science Teacher

The Association for Science Education (ASE) in its policy statement "Education through Science" (1981), argued that, in planning and developing the curriculum, teachers should show that science can be explored from the viewpoint of its applications, leading to development of an appreciation and understanding of the ways in which science and technology contribute to the worlds of work, citizenship, leisure and survival. To implement STS in science education, the training and psychological preparation of the teaching force must be considered (Jegede, 1988). According to Za'rour, the unfamiliarity of teachers with the required teaching models and approaches could hinder the introduction of STS education in schools. Similarly, Rubba (1991) suggests that, STS has not attained the level of implementation recommended by NSTA because the majority of the science teachers are not prepared to teach STS. Therefore, before STS teaching practices can be fully developed and put into practice appropriately, science teachers' beliefs and values about science education must be restructured in such a way that, they can fully appreciate what the notion of responsible citizen action on STS issues as a goal of a school science education.

Another barrier for implementing STS in the class as Aikenhead (1984) is the socialization process that science teachers go through during their preparation in the university. When studying science at university, teachers experience a process of socialization into a discipline (Barnes, 1985; Ziman, 1994). During experience, teachers developed deep-seated values about science teaching (Aikenhead, 1984; Pedretti & Hodson, 1995). Aikenhead (2000) mentions that pre-service education socializes science teachers to believe that their responsibility is to socialize their students into a specifically scientific discipline. Therefore, to implement an STS science course successfully, from a teacher's point of view, the best way to initiate students into a discipline is the same way the teacher was initiated (Aikenhead, 1984). Aikenhead (2000) emphasised change the deep-seated, personally cherished values of a number of teachers. In addition to that change, teachers must add new methods to their repertoire of instructional strategies. A new routine of instruction is best learned from fellow teachers who have practical credibility. A successful plan of action will involve few cleverly selected teachers chosen to go through an intense in-service experience. These teachers then become in-service leaders in their own regions of the country, passing on their leadership expertise to other teachers who repeat the in-service process in their own communities. An example of this approach in preparing STS teachers is presented by Pedretti and Hodson's study (1995). Pedretti and Hodson conducted a one-year study with six science teachers who were positively predisposed to STS science. The aim was to produce usable curriculum materials through teacher ownership and understanding, all organized around an action research group. Pedretti and Hodson documented teachers' increased understanding in terms of the nature of science, developing curriculum materials, personal and professional development, and collaboration. In addition, participants reaffirmed many of their personal theories and practices.

Fensham (1988) refers that science teachers state that the science disciplinary background has not prepared them for STS. An undergraduate education in a science discipline rarely allows students to be aware of the controversy in pure science itself, and its patterns of teaching and learning do not usually include discussion of the merits of arguments or debating about the quality of the empirical evidence or the concepts on which this is based. Through the findings of his case study with 5 science teachers in the Prairie high school to explore the personal reasons, beliefs and dilemmas underlie their decision; Aikenhead (1984) suggested three requirements so the teacher could reflect the NSTA's 1982 position statement supporting a science-technology-society approach to science teaching. These requirements are: (1) an alteration in the teachers' values concerning valid science content, (2) an evaluation of socialising function of their new courses, and (3) a reformulation of the practical holistic decision-making system that currently supports and sustains them on a day to day basis.

STS teaching requires new models for pre-and in-service teacher education. Yager (1996) argues that the greatest problem associated with shifts to STS teaching is the failure of most teachers to have experienced study and learning themselves as STS, i.e., learning in the context of human experiences. In its policy statement "Education through Science" (1981), the Association for Science Education (ASE) argued that, in planning and developing the curriculum, teachers should show that science can be explored from the viewpoint of its applications, leading to development of an appreciation and understanding of the ways in which science and technology contribute to the worlds of work, citizenship, leisure and survival.

To implement STS in science education, the training and psychological preparation of the teaching force must also be considered (Jegede, 1988). According to Za'rour, the unfamiliarity of teachers with the required teaching models and approaches could hinder the introduction of STS education in schools. Similarly, Rubba (1991) suggests that STS has not attained the level of implementation recommended by NSTA because the majority of the science teachers are not prepared to teach it. Therefore, before STS teaching practices can be fully developed and put into practice appropriately, science teachers' beliefs and values about science education must be restructured in such a way that they can fully appreciate what the notion of responsible citizen action actually is on STS issues as a goal of school science education.

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Aikenhead (2000) also emphasised the need to change the deep-rooted, personally-cherished values of a number of teachers. In addition to such change, teachers must add new methods to their repertoire of instructional strategies. A new routine of instruction is best learned from fellow teachers who have practical credibility. A successful plan of action will involve a few cleverly-selected teachers who are chosen to go through an intensive in-service experience. These teachers then become in-service leaders in their own regions of the country, passing on their leadership expertise to other teachers who repeat the in-service process in their own communities. An example of this approach in preparing STS teachers is presented in the study by Pedretti and Hodson (1995), who conducted a one-year study with six science teachers who were positively predisposed towards STS science. The aim was to produce usable curriculum materials through teacher ownership and understanding, all organized around an action research group. Pedretti and Hodson documented the increased understanding among teachers in terms of the nature of science, developing curriculum materials, personal and professional development, and collaboration. In addition, participants reaffirmed many of their personal theories and practices.

Fensham (1988) notes that science teachers state that the science disciplinary background has not prepared them for STS. An undergraduate education in a science discipline rarely allows students to be aware of controversies in pure science itself, and its patterns of teaching and learning do not usually include discussion of the merits of arguments, or debate about the quality of the empirical evidence or the concepts on which this is based. Through the findings of his case study exploring the personal reasons, beliefs and dilemmas underlying the decision of five high school science teachers to teach, Aikenhead (1984) suggested that there were three requirements for enabling a teacher to reflect the NSTA's 1982 position statement in support of a science-technology-society approach to science teaching. These requirements were: (1) an alteration in the teachers' values concerning valid science content, (2) an evaluation of the socialising function of their new courses, and (3) a reformulation of the practical holistic decision-making system that currently supported and sustained them on a day- to-day basis.

The success of science education reform depends on the teachers' ability to integrate the philosophy and practices of current programmes of science education reform with their existing philosophy (Bybee, 1993). After reviewing the research, Fang (1996) pointed out that practice could be consistent with a teacher's beliefs. Pajares (1992) supported the notion that teachers' beliefs influence their perceptions, which in turn affects their behaviour in the classroom. Thus, when considering the STS approach to science education, teacher beliefs about STS implementation require attention (Carroll, 1999). Without this attention, negative beliefs concerning STS implementation and inquiry learning could defeat the reform movements emphasising STS.

Carroll (1999) argues that teachers must be involved in the actual development of the STS curriculum so they can build their knowledge concerning STS teaching and learning themes, and reform their beliefs along the way. Teachers must also have the opportunity to develop their views and beliefs about STS. In this respect, Thirumarayana (1998) suggests that before STS instruction can be implemented, teachers must first build upon their interests and use that knowledge to develop conceptual understanding. Central to the realization of any curriculum implementation goal is the need for information concerning the beliefs that teachers hold about curriculum implementation, and the origins of these beliefs. As Munby (1984) has clearly and articulately argued, “teachers’ beliefs and principles are contextually significant to the implementation of innovations” (p.28). Research supports the idea that teachers are crucial agents of change for educational reform and that teachers’ beliefs are precursors to change (Fishbein & Ajzen, 1975; Pajares, 1992).

From this point implementing STS in science curricula is based on the contribution of teachers, and their convictions or beliefs about such innovations. Noss and Hoyles (1996), for instance, argue that the implementation of any innovation that neglects to take account of the teachers and their work situation as mediators of the innovation, is bound to fail. Therefore it is essential to take science teachers’ beliefs and practices into account and also the factors that shape or influence their beliefs and practices in order that they can be dealt with (Mansour, 2007a). Thus, to genuinely understand teachers’ beliefs and practices, the next section of this paper will try to clarify the different views about the nature of teachers’ beliefs, teachers’ beliefs about teaching and learning, the relationship between beliefs and practice.

## Teachers’ Beliefs about teaching and learning science through STS

Researchers often categorize teacher beliefs as either behaviourist (transmissionist) or constructivist. It should be noted from the start, however, that such a dichotomy, while useful in terms of being able to clearly categorize beliefs, may be simplistic and misleading. Theories of learning such as constructivism are so diverse (Ernest, 1994) that it is questionable whether we can possibly categorize sets of beliefs in terms of a behaviourist/constructivist dichotomy. Not only are these theories of learning complex and open to a variety of interpretations, but teachers' beliefs themselves are also complex and sometimes contradictory, and therefore resist a concise classification.

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 some teachers view teaching as a process of knowledge transmission, while others view it as a process of guiding children's learning or as a process of developing social relationships. He also distinguishes between teachers' beliefs based on their experience. Pre-service teachers start with control-oriented belief systems that emphasize the importance of maintaining order and good discipline, and guiding the activities of the children. During training, these attitudes become more liberal and child-centred. However, when teachers enter full-time teaching, they revert to a control-oriented belief system.

Bell and Gilbert (1996) outline two extreme positions concerning the nature of teaching that can take place in a given classroom. The first states that the predominant belief is that the role of a teacher, as an expert in this knowledge, is to present such knowledge directly to students in a logical sequence. The second position is based on the belief that knowledge is constructed by individuals, and that the role of the teacher is to be a facilitator who allows students to reconstruct, extend or replace their existing knowledge. Teachers' beliefs about science teaching are therefore extremely varied. Some teachers believe in teaching students by lecturing or direct teaching. Others reflect constructivist views of learning and teaching, by using co-operative learning or inquiry. However, the majority of science teachers are more likely to mix features of science teaching methods. A teachers' belief about science teaching is more likely to include various aspects of several modes of teaching than it is to fit perfectly into the description of a single model (Mansour, 2007a).

Tsai (2002) argues that the beliefs of many teachers who hold traditional views of teaching science, learning science, and the nature of science, may stem from the problem of their own school science experience. Science classes, laboratory exercises, and relevant activities in teacher education programmes may have reinforced these "traditional" views. In the same way, Trumbull and Slack (1991) believe that teachers fail to develop constructivist-oriented ideas about teaching and learning because they have all experienced success in the existing (i.e. traditional-oriented) educational environments. Therefore, they may not perceive potential insights about constructivist conceptions of learning and teaching.

Teachers' beliefs about learning science refer to their conceptions of the process of learning science, what behaviours and mental activities are involved on the part of the learner, and what constitutes appropriate and prototypical learning activities. The central question of enquiry is: how and in what way should students learn science? An underlying feature of a particular view of learning, which can be seen to be implicit in some science teaching, has been described by Barnes (1973) as a "transmission view". He describes the teacher who adopts this view as operating a 'speaking tube' down which s/he sends knowledge when s/he asks pupils questions or tells them to write. He considers that it is primarily in order to test whether they have in fact received the knowledge transmitted by the teacher. A teacher who follows a transmission mode as one who (Barnes, 1973; Trumbull & Slack, 1991; Bell & Gilbert, 1996):

- believes knowledge to exist in the form of public disciplines which include content and criteria performance. This often means that they see themselves as 'authorities' in a subject;
- values the learner's performances in so far as they conform to the criteria of discipline;
- sees the teacher's task to be the evaluation and correction of the learner's performance, according to criteria of which s/he is guardian;
- sees the learner as an un-informed acolyte for whom access to knowledge will be difficult since he must qualify himself through tests of appropriate performance.

According to Scott (1987), within the "transmission view" a tacit assumption being made by the teacher is that the students do not bring relevant ideas of their own to lessons and that they act simply as recipients of knowledge, adding the information to their "memory store". Thus, chunks of information are transferred from teacher to pupil during teaching:

This view is reflected in a variety of ways: through the teacher's approach to the curriculum, in the type of teaching strategies adopted by the teachers, and in the way students are assessed (Scott, 1987). As for the "transmission view" of learning, the curriculum is seen as the list of things to be taught. Science is thus presented as a catalogue of "facts". Also, the emphasis is upon "closed" teaching strategies, which support the flow of information from teachers to students. Moreover, the interactions between the teacher and students in the class have the traditional characteristics of the classroom, with the teacher asking a series of closed questions and students playing the game of "guess what teacher is thinking". According to a "transmission view", 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.

As for a behaviourist perspective, the transmission of information from teacher to learner is essentially the transmission of the response appropriate to a certain stimulus. Thus, the point of education is to present the student with the appropriate repertoire of behavioural responses to specific stimuli, and to reinforce those responses through an effective reinforcement schedule An effective reinforcement schedule requires consistent repetition of the material; small, progressive sequences of tasks; and continuous positive reinforcement. Without positive reinforcement, learned responses will quickly become extinct. This is because learners will continue to modify their behaviour until they receive some positive reinforcement (Skinner, 1976). 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 though STS. 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). As Hodson (1992) has stated, Students develop their conceptual understanding and learn more about scientific inquiry by engaging in scientific inquiry, provided that there is sufficient opportunity for and support of reflection.

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). The goal of science teaching might be to develop individuals who think for themselves (Newbrough, 1995). Such people have some measures of control over the meaning they make of their experiences, and the ways in which they construct their lives and ideas. Constructivism places primary emphasis on the independence of each person's interpretation of his or her own experience (Roth, 1994). The implications of constructivist views for the science classroom include the ample use of hands-on investigative laboratory activities, a classroom environment which provides learners with a high degree of active cognitive involvement, the use of cooperative learning strategies, and the inclusion of test items which activate a higher level of cognitive processes. Also, the main pedagogical implication is that the active learner's construction of his/her own understanding can be facilitated by teachers who provide stimulating and motivational experiences which challenge students' existing conceptions and involve them actively in the teaching/learning process (Gil-Pérez et al., 2002; Matthews, 2002;  Matthews, 1997).

Within the constructivist view, as mentioned by Watts (1994), science needs to be relevant to students' everyday lives since this real context provides the roots from which their studies should be drawn. It needs to be related to their hobbies and modern lifestyles; to current affairs and television news; to people and practices in the world. Watts (1994) also notes that the movement for relevance is not new and that it helped 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.

Constructivist teachers of science promote group learning, where two or three students discuss approaches to a given problem with little or no interference from the teachers. In contrast to traditional teachers who see that a given problem has only one solution, constructivist teachers would rather explore how students see the problem and why their paths toward solutions seem promising to them. Constructivist teachers also help students connect their own prior experiences to current situations (Yager, 1995). However, the teachers' roles are different in the behaviourist approach, where a teacher's task consists of providing a set of stimuli and reinforcements that are likely to make students emit behaviour (Yager, 1995). In real science classes, science students seldom see anything they study as having any relevance or applicability in their own lives.

## Conclusion

Science teachers are the most important key in shifting toward STS education. Therefore, for a successful shift to occur, a science teacher has to have a very complete understanding of what STS education is about and the philosophy behind it. They also need support and help from other people who involved in education. According to Heath (1992), many good STS units and programs result from individual teachers striking out on their own filled with enthusiasm, ability, and dedication to the importance of STS, but with little support. Without support, it is difficult to expend or maintain the quality of ongoing STS instruction. Technology, interdisciplinary teacher teams, partnership with universities could be sources for support (p. 52).

The success of STS education reform depends on the teachers' ability to integrate the philosophy and practices of STS education reform with their existing philosophy. This manuscript supported the notion that teachers' beliefs about STS education influence their behaviours in the classroom. Thus, when considering the STS approach to science education, teacher beliefs about STS implementation require attention. Without this attention, negative beliefs concerning STS implementation could defeat the reform movements emphasising STS.

Teaching science Within STS Paradigm is derived by both the students and the teacher working cooperatively together, or from suggestions offered by students based on their interests and life issues confronting them. So, it is very important to consider students' views, interests and attitudes when developing the science curricula.

## References

Agin, M. L. (1974). Educational for Scientific Literacy: A conceptual frame of reference and some applications. *Science Education*, 58, 403-415.

Aikenhead, G. (1984). Teacher decision making: the case of Prairie high. *Journal of Research in Science Teaching, 21*(2), 167-186.

Aikenhead, G. (1994). What is STS science teaching? In J. Solomon & G. Aikenhead (Eds.), *STS education international perspectives on reform* (pp.47-59). London: Teachers college, Columbia University.

Aikenhead, G. (2000). STS in Canada: From policy to student evaluation. In D.D. Kumar & D.E. Chubin (Eds.), *Science, technology, and society: A sourcebook on research and practice* (pp.49-89). New York: Kluwer Academic/Plenum Publishers

ASE (1981). *Education through Science*. ASE: Hatfield.

Barnes, B. (1985). *About science*. Oxford: Basil Blackwell.

Barnes, D. (1973). Language in the classroom. London: Open University Press, Milton Keynes.

Bell, B., & Gillbert, J. (1996). *Teacher development: A model from science education*. London: Falmer Press.

Bentley, D., & Watts, M. (1989). *Learning and teaching in school science: Practical alternatives*. Philadelphia: Open University Press, Milton Keynes.

Blades, D. W. (1997). *Procedures of power & curriculum change*. New York: Peter Lang.

Bruner, J. S. (1960). *The process of education*. New York: Vintage Books.

Bybee, R. (1993). *Reforming science education: Social perspectives and personal reflections*. New York: Teachers College Press.

Bybee, R. W. (1987). Science education and Science-Technology-Society (S-T-S) theme. *Science Education, 71* (5), 667-683.

Calderhead, J. (1996). Teachers: Beliefs and Knowledge. In D. Berliner & R. Calfee (Eds.), *Handbook of educational psychology*, (pp. 708-725). New York: Macmillan.

Carin, S. & Sund, R. (1989). *Teaching science through discovery*, 6th Ed., Columbus, Ohio: Merrll Publication Co.

Carroll, T. M. (1999). *Developing partnerships: teacher beliefs and practices and the STS classroom*. Proceedings of the 1999 Annual international conference of the association for the Education Teachers in Science (pp.331-338). Greenville, NC: Association for the Education of Teachers in Science. (ERIC Document Reproduction Service No. ED 431626).

Dimopoulos, K., & Koulaidis, V. (2003). Science and technology education for citizenship: the potential role of the press. *Science Education, 87* (2), 241-256.

Duggan, S. & Gott, R. (2002). What sort of science education do we really need? *International Journal of Science Education, 24* (7), 661-679.

Eijkelhof, H., & Lijnse, P. (1988). The role of research and development to improve STS education: experiences. *International Journal of Science Education, 10* (4), 464-474.

Ernest, P. (1994). *An introduction to research methodology and paradigms. Educational Research Monograph Series*, School of Education, University of Exeter.

Fang, Z. (1996). A review of research on teacher beliefs and practices. *Educational Research, 38*(1), 47-64.

Fensham, P. J. (1988). Approaches to teaching of STS in science education. *International journal of science education, 10* (4), 346-356.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior: An introduction to theory and research*. London: Addison-Wesley.

Fox, D. (1983). Personal theories of teaching. *Studies in higher Education, 8*(2), 151-163.

Gil-Perez, D., Guisasola, J., Moreno, A., Cachapuz, A., Pessoa de Carvalho, A., Torregrosa, J., Salinas, J., Valdes, P., Dumas-Carre, A., Tricarico, H., & Gallego, R. (2002). Defending Constructivism in Science Education. *Science & Education* 11, 557–571.

Hart, E. P., & Robottom, I. M. (1990). The Science-technology-society movement in science education: A critique of the reform process. *Journal of Research in Science Teaching, 27*(6), 575-588.

Heath, P.A. (1992). Organizing for STS teaching and learning: the doing of STS. *Theory into Practice, Volume xxxi*, 1, winter, 52-58.

Hodson, D. (1992). In Search of a Meaningful Relationship: An Exploration of Some Issues Relating to Integration in Science and Science Education, *International Journal of Science Education. 14*(5), 541–566.

Hofestein, A., Aikenhead, G. S., & Riquarts, K. (1988). Discussions over STS at the Fourth IOSTE Symposium. *International journal of Science Education, 10*(4), 357-366.

Hurd, P. D. (1998). Scientific literacy: new minds for changing world. *Science Education, 82* (3), 407-416.

Jegede, O. J. (1988). The development of the science, technology and society curricula in Nigeria. *International journal of science education, 10*(4), 399-408.

Jenkins, E. W. (1999). School science, citizenship and the public understanding of science. *International Journal of Science Education, 21* (7), 703-710.

Kahl, S., & Harms, N. (1981). Project synthesis: Purpose, organization and procedures. In Harms, N., & Yager, R. (Eds.), *What research says to the science teacher*, Vol. 3, 5-11.

Kliebard, H. M. (1979). The drive for curriculum change in the United States, 1890-1958: I - The ideological roots of curriculum as a field of specialization. *Journal of Curriculum Studies*, 11, 191-202.

Kolstoe, S. D. (2001). Scientific literacy for citizenship: tools for dealing with the science dimension of controversial socioscientific issues. *Science Education, 85* (3), 291-310.

Longbottom, J., & Butler, P. (1999). Why teach science? Setting rational goals for science education, *Science Education, 83* (4), 473-492.

Mansour, N. (2007). Challenges to STS education: Implications for Science Teacher Education. *Bulletin of Science, Technology & Society, 27*, (6), 482-497.

Mansour, N. (2007a). *Exploring Science teachers' orientations towards teaching and learning of science*. A paper presented to the European Educational Research Association (EERA) annual conference at Faculty of Psychology and

Educational Sciences, University of Ghent, Belgium (Ghent), 17th to 21st September.

Marshall, H. H. (1992). *Reconceptualizing learning for restructured schools*. Paper presented at the annual meeting of American Educational Research Association, San Francisco, C.A.

Martin, B., & Beder, S. (1993). The arrogance of scientists. Chain Reaction, 68, 16-17.

Matthews, M. R. (1997). Introductory comments on philosophy and constructivism in science education, *science & technology*, 6, 5-14.

Matthews, M. R. (2002). constructivism and science education: A further appraisal, *Journal of Science Education and Technology, 11* (2), 121-134.

Munby, H. A. (1984). A qualitative approach to the study of a teacher's beliefs. *Journal of Research in Science Teaching, 21*(1), 27-38.

Newbrough, J.R. (1995). Toward community: a third position. *American Journal of Community Psychology*, 23, 9-7.

Noss, R., & Hoyles, C. (1996). *Windows on mathematical meaning*, Dordrecht: Kluwer Academic Publishers.

NSTA (1993). Science/Technology/Society: A new effort for providing appropriate science for all. In R. Yager (Ed.), *What research says to science teacher: the science, Technology & Society Movement* (3-5). Washington DC, National Science Teachers Association. Vol. 7, 3-6.

on of controversial socioscientific issues. *Science Education*, *85* (3), 291-310.

Ost, D. H., & Yager, R. E. (1993). Biology, STS & the next steps in program design & curriculum development. *American Biology Teacher, 55*(5), 282-287.

Pajares, M. F. (1992). Teachers' beliefs and education research: Cleaning up a messy construct. *Review of Education Research, 62,* 307-332.

Pedretti, E., & Hodson, D. (1995). From rhetoric to action: Implementing STS education through action research. *Journal of Research in Science Teaching, 32* (5), 463-485.

Price, R. F., & Cross, R. T. (1995). Conceptions of science and technology clarified: improving the teaching of science. *International Journal of Science Education, 17* (3), 285-293.

Quicke, J. (2001). The science curriculum and education for democracy in the risk society. *Journal of curriculum Studies, 33* (1), 113-127.

Ramsey, F. P. (1993). *The foundation of mathematics, and other logical essays*. London: Routledge.

Ramsey, J., & Hungerford, H. (1989). The effects of issue investigation and action training on eighth-grade students' environmental behavior. *The Journal of Environmental Education, 24* (3), 31-36.

Roth, W. M. (1994). Experimenting in a constructivist high school physics laboratory. *Journal of Research in Science Education, 31* (2), 197-223).

Rubba, P. A. (1991). Integrating STS into school science and teacher education: Beyond awareness. *Theory into Practice*, 30, 303-308.

Schwab, J. (1966). *Teaching science as inquiry*. Cambridge: Harvard University Press.

Scott, P. (1987). *A constructivist view of learning and teaching in science*. Leeds, England, UK: Centre for Studies in Science and Mathematics Education, University of Leeds.

Skinner, B. F. (1976). *About Behaviorism*. New York: Vintage Books.

Solomon, J. (1993). *Teaching Science, Technology and Society*. Buckingham: Open University Press.

Thirumarayana, M. O. (1998). An explanatory study of the relationships among science, technology, and society (STS) issues as conceived by fifth grade students. *Journal of Elementary Science Education, 10* (1), 60-75.

Trumbull, D., & Slack, M. J. (1991). Learning to ask, listen, and analyze: using structured interviewing assignments to develop reflection in pre-service science teachers. *International Journal of Science Education, 13* (2), 129–142.

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

Waks, L. J. (1987). A technology credo. *Bulletin of Science, technology & Society, 7*(1-2), 357-366.

Watts, M. (1994). Constructivism, re-constructivism and task-orientated problem-solving. In P. Fensham, R. Gunstone, & R. White (Eds.), *The content of science: A constructivist approach to its teaching and learning* (pp. 39-58). London: The Falmer Press.

Welch, W. W. (1981). Inquiry in school science. In N. C. Harms and R. E. Yager (Eds.) *what research says to the science teacher* (35-72). Washington, Dc: National Science Teacher Association.

Wiesenmayer, R., & Rubba, P. (1999). The effects of STS issue investigation and action instruction versus traditional life science instruction on seventh grade students' citizenship behaviors. *Journal of Science Education and Technology, 8* (2), 137-144.

Wraga, W. G., & Hlebowitsh, P. S. (1991). STS education and the curriculum field. *School Science and Mathematics, 91*(2), 54-59.

Yager, R. E. (1990). STS: Thinking over the years. *The science teacher, 57*(3), 52-55.

Yager, R. E. (1993). Science - Technology – Society as Reform. *School Science and Mathematics, 93* (3), 145-151.

Yager, R. E. (1996). *Science/Technology/Society as reform in science education*. Albany: State University of New York Press.

Yager, R., & Tamir, P. (1993). STS approach, reasons, intentions, accomplishments and outcomes. *Science Education, 77*(6), 637-658.

Za'Rour, G. I. (1987). Forces hindering the introduction of STS education in schools. In Jegede, O. J. (1988) The development of the science, technology and society curricula in Nigeria. *International journal of science education, 10* (4), 399-408.

Ziman, J. (1980). *Teaching and learning about Science and Society*. Cambridge, MA: Cambridge University Press.

Ziman, J. (1994). The rationale of STS education is in the approach. In J. Solomon & G. Aikenhead (Eds.). *STS education: international perspectives on reform*. (pp.21-31). London: Teachers College Press.

## Biographical Note

**Nasser Mansour** is a teacher fellow at School of Education and Lifelong Learning, University of Exeter, United Kingdom. Also, he is a Lecturer in Science Education at the Faculty of Education, Tanta University, Egypt.

He holds BSc (grade Very Good/Honours) in Physics & Chemistry Education, and an MA in Science Education (grade Excellent) from the Faculty of Education, Tanta University, Egypt. His PhD in Science Education is from the School of Education and Lifelong Learning, University of Exeter. He also holds a Diploma in Understanding Children from the Open University, United Kingdom.

He originated the "Personal Religious Beliefs (PRB) Model", which explains the process of shaping and reshaping teachers' beliefs and practices. He is a reviewer for the British Educational Research Association (BERA) conference. He is a member of several educational associations; BERA (British Educational Research Association, UK); ESERA (European Science Educational Research Association, Netherlands); BAAS (British Association for the Advancement of Science, UK); and NARST (National Association for Research in Science Teaching, USA).

His main research interests are in aspects of teaching and learning in science, including STS (Science, Technology and Society education); controversial issues, scientific literacy, the relationship between religion and science education; learners' ideas, misconceptions, alternative conceptions and alternative frameworks; constructivism in science education; learner thinking; creative thinking in science explanations in science; teaching about the nature of science; science teachers' beliefs and practices, teacher professional development; and Grounded Theory.

Publications:

Mansour, N. (2007). Challenges to STS education: Implication for science teacher education. *Bulletin of Science, Technology & Society*, 27, (6), 482-497.

Mansour, N. (2008). The experiences and personal religious beliefs of Egyptian science teachers as a framework for understanding the shaping and reshaping of their beliefs and practices about Science-Technology-Society (STS). *International Journal of Science Education. 30*(12), 1605-1634.