Teaching for scientific literacy: Bangladeshi teachers' perspectives, practices and challenges

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Contents

Abstract

This paper reports on the way three Bangladeshi science teachers perceive scientific literacy, translate their perspectives into classroom teaching, the values they consider pertaining scientific literacy and the issues they perceive as challenging in their teaching. Employing a case study approach, data in this research were gathered through observing each teacher teach a series of lessons of the General Science course, interviewing them twice – once before and once after the class observation, and interviewing their students in focus groups. Analysis of these data reveals that whilst participating teachers held a range of perspectives of scientific literacy, in practice they demonstrated limited capacity to translate their perspectives into their classroom teaching practice. They mostly promoted a culture of academic science that reduces the capacity to make science important to all students in their everyday lives and in developing scientifically literate students. The data also reveal that whilst teachers mostly perceived the importance of the curriculum-identified values, they experienced difficulties in finding suitable teaching approaches to promote these values. These findings may contribute to understanding science teachers' efforts to promote scientific literacy in a teaching-learning context that challenges teachers with an academically oriented, outdated and rushed curriculum, large class size, and a traditional assessment-oriented education system.

Keywords: scientific literacy; science values; nature of science; science teaching; Bangladesh

Introduction

During the 1980s, Fensham's (1985) call for a *Science for All* was recognised worldwide as a commitment to provide science to all students, not just to the elite. Subsequently, this slogan has been modified to one of *Scientific literacy* (Law, Fensham, Li, & Wei, 2000), which is advocated worldwide as a goal of school science education as for example in the USA (American Association for the Advancement of Science [AAAS], 1993), in the UK (Millar & Osborne, 1998), or in Australia (Goodrum, Hackling, & Rennie, 2001). In line with this global trend, junior secondary science education in Bangladesh aims to provide a good foundation in science for all students to enable them to use their science learning in everyday life (National Curriculum and Textbook Board [NCTB], 1995). This aim is consistent with the call for scientific literacy, which argues for engaging students with science in everyday life (Tytler, Osborne, Williams, Tytler, & Clark, 2008).

In the Bangladesh Junior Secondary Curriculum Report, it has been agreed that "in these days, the importance of acquiring scientific knowledge and skills is unavoidable for improving the quality of lives, solving everyday problems and making decisions" (NCTB, 1995, p. 353). In order to provide such knowledge and skills, the General Science course at the junior secondary level is compulsory for all students, even though almost 75% students choose the non-science groups after this level (Bangladesh Bureau of Educational Information and Statistics [BANBEIS], 2006). The junior secondary General Science curriculum therefore should provide a good foundation in science for all students including those who will take further studies in science. The emphasis in the curriculum needs to cater for both of these groups as the former group needs a solid foundation in science in preparation for being effective citizens, while in addition to this the latter group needs a good foundation to prepare them for further study in science. This emphasis, however, does not always remain in balance in the curriculum, with teachers often focussing more on the good foundation for the future science study group (Sarkar, 2009).

This paper examines how scientific literacy is considered in junior secondary science classes in Bangladesh. In order to do this, four research questions have been framed:

- What are the teachers' perspectives of scientific literacy?
- How are teachers' perspectives of scientific literacy translated into classroom teaching?
- What values teachers consider in relation with scientific literacy and how are they considered?
- What issues do teachers perceive as challenging in their teaching for scientific literacy

Scientific Literacy and Science Knowledge

No universally accepted consensus exists for the conceptions of scientific literacy (DeBoer, 2000), and this may be due to the dependence of scientific literacy on context. Roberts (2007) attempts to track the different meanings attached to scientific literacy and categorize the various definitions into two main extremes, which he calls Vision I and Vision II. At the one extreme, Vision I starts with the products and processes of science for science teaching and learning. These products and processes are then exemplified by situations or contexts in which science may have a role. In this manner, contexts are used as add-ons to traditional academic content that is often abstract and is not connected to immediate applications. The other extreme, Vision II starts with situations or contexts, and then reaches into science to find the relevant content. In this manner, Vision II focuses on the context in which science is embedded rather than considering the science content in isolation. This Vision II aims "to enculturate students into their local, national, and global communities" (Aikenhead, 2008, p. 1). Table 1 illustrates the practices of these two Visions in relation with scientific literacy.

Table 1. Vision I and Vision II – in Practice

Vision I	Vision II
Curriculum is aimed to educate future scientific community (pre-professional training)	Curriculum is aimed to make most of the learners as scientifically literate at some level
Content is often abstract and is not connected to immediate applications	Content has obvious need to function effectively in society
Learning science occurs through direct transfer of science content to students from teachers or prescribed curriculum materials	Learning science occurs as a result of placing learners at the heart of instructional exchanges
Students find difficulty in relating science with their personal and social life	Students find the relevance of science with their personal and social life

As Table 1 shows, in Vision I, science curriculum is designed for the students who wish to take a science-related career; content mostly comes from pure academic sciences, and is often irrelevant to the students' lives and abstract in nature; and learning is more teacher-centred. On the contrary, in Vision II, curriculum is designed to give access to basic scientific literacy for the majority of students; content is mostly applied in students' life context and thus, functional in nature; and learning is student-centred. Providing students with everyday context for learning science, the Vision II helps students continue and sustain this learning along their entire life (Roth & Barton, 2004) and has a strong influence on the use of their science knowledge (Layton, Davey, & Jenkins, 1986).

In discussing the implications of these two visions, Aikenhead (2008) points out that a Vision I approach results in decreased enrolments in science along with little or no scientific literacy, while a Vision II approach can promote scientific literacy to a reasonable degree. However, Vision II is an extreme curricular orientation that could be challenged by the power politics (Roberts, 2007) in the case when a single curriculum is intended to satisfy the need for both a future science study group and scientific literacy for all. In such a context, a combination of Vision I and Vision II orientations (i.e., Vision I-II) could satisfy both of these major purposes of school science education. This Vision I-II orientation could provide a life-oriented and relevant science education to all students that would encourage more students to study further in science and engage in a science related career. Providing such life-oriented and relevant science education could help students become informed users and consumers of science knowledge.

Science content knowledge is important for both intrinsic and instrumental justifications as suggested by Millar (1996). Intrinsic justification refers to cultural aspects, that is, scientific knowledge can help people satisfy their curiosity about the natural world, which is also very important in learning (Howes, 2001). On the other hand, the instrumental justification refers to the utilitarian aspects, that is, scientific knowledge is necessary as a foundation for making informed practical decisions about everyday matters, participating in decision-making on science-related issues; and working in science and technology related jobs (Millar, 1996).

whilst both of these justifications suggest promoting science knowledge that has relevance to, and importance in students' everyday decision-making as well as helping to satisfy their curiosity about the natural world around them (i.e., aims consistent with Vision II scientific literacy), a case may still be made for academic science knowledge (e.g., structure of atom). This academic science knowledge may not have immediate application in students' everyday lives but may have importance in accommodating some students wishing to study further in science and to take a science related career. Thus it is argued that in a common curriculum for all students, for example, in Bangladesh (NCTB, 1995), the curriculum orientation could adopt a Vision I-II approach. In a Vision I-II curriculum orientation, it is not intended that the pure content disappears, but is argued that the curriculum needs to have more emphasis on science knowledge that has relevance to, and importance in students' everyday lives (Aikenhead, 2008). Such an emphasis may help students to become informed users and consumers of science knowledge who would be able to:

- ask, find, or determine answers to questions derived from curiosity about everyday experiences;
- read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions;
- to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately; and

- make informed decisions about the environment and their own health and well being.

(Summarised from Goodrum, et al., 2001; National Research Council [NRC], 1996)

However, people's choice of action is formed by the values they pose (Tan, 1997) and therefore, their decision-making is often guided by their values (Rennie, 2007). Values have therefore, been considered as an important facet of scientific literacy (Koballa, Kemp, & Evans, 1997; Organisation for Economic Co-operation and Development [OECD], 2006) and are discussed below.

Scientific Literacy and Values

In this research, since scientific literacy is perceived as related to the making and evaluating of decisions and arguments, values, therefore, are crucial for the conceptions of scientific literacy in this research and have been defined as

> principles, fundamental convictions, ideals, standards or life stances which act as general guides or as points of reference in decision-making or the evaluation of beliefs or action and which are closely connected to personal integrity and personal identity. (Halstead, 1996, p. 5)

The junior secondary General Science curriculum in Bangladesh states five values to be promoted: open-mindedness, rational thinking, respect for others' opinions, intellectual honesty, and curiosity (NCTB, 1995, p. 354). This research focuses on these five values as interpreted in Table 2. Whilst there may be other values that could be considered [for example, Hodson and Reid (1988b, p. 106) listed 17 values to be incorporated in school science curriculum for designing appropriate learning experiences], these five should be represented in any science endeavour, including in the science classroom. Moreover, these values might be viewed as important in making decisions and arguments, and therefore as important for scientific literacy as explained below.

Hare (2009) argued that promoting open-mindedness requires an encouragement of curiosity and wonder in students, which in turn encourages them to ask questions and challenges them to support their own views with evidence and argument. Also, open-mindedness requires a person to consider all available alternatives (Hare, 2009); additionally, rational thinking would help this person to choose among the alternatives (Tan, 1997), and help him/her to reach an informed decision or a conclusion (Hare, 1979). Moreover, an individual's willingness to communicate a consistent conclusion based on evidence is associated with the value of intellectual honesty (Asia and the Pacific Programme of Educational Innovation for Development [APEID], 1991). Despite holding such a reasoned view, however, the open-minded person recognises the unavoidability of diversity in people's ideas and beliefs (Hare, 2009), and thus respects others' right to hold or express their own opinions or views. In this sense, the values of open-mindedness and respect for others' opinions are very much related to each other. It may appear from the above discussion that the five values considered in this research may influence people to use science knowledge in making and evaluating decisions and arguments and therefore, are important for scientific literacy.

Table 2. Meaning of the Target Values

Target value	Meaning
Open-mindedness	Open-mindedness refers to a consideration of alternative ideas and proposed solutions to an issue (Hare, 2009) that one may not have previously entertained (Loughran, 1994). Open-mindedness, therefore, is the willingness to change one's mind in the light of new evidence as well as willingness to suspend judgment if there is insufficient evidence (Hodson & Reid, 1988a).
Rational thinking	Rational thinking refers to being "systematic and logical in thinking through ideas" (Hildebrand, 2007, p. 52). Rational thinking, therefore, emphasises "argument, reasoning, logical analysis and explanations" (Corrigan & Gunstone, 2007, p. 145).
Respect for others' opinions	Respect for others' opinions may be considered as a supporting value of science education (Tan, 1997) that may refer to one's admiration for other's right to hold or express their opinions. This value is very important in this diverse world because if there is less respect for the diversity of opinions, this may lead the powerful people to force their opinions on everyone else.
Intellectual honesty	Intellectual honesty may refer to one's integrity in performing intellectual activities, such as thoughts and communication. The notion of intellectual honesty may include (APEID, 1991): an honest reporting of observed facts and phenomena (e.g., an experiment); "an honest reporting of opinions, views and preferences, if these impinge upon ones personal belief" (p. 62) and avoiding fabrication and intentional interpretation of data to suit one's beliefs.
Curiosity	Curiosity refers to "wondering how things work; possessing an orientation to inquiry, to speculation, to chasing ideas and testing them against evidence" (Hildebrand, 2007, p. 53). It is the "spark that ignites research" (Tan, 1997, p. 561).

Methodology

Research Design and Data Sources

In this paper, we report some data from a large-scale research, which adopted a qualitative-dominant design. The research first employed a questionnaire to gather responses from a number of teachers teaching the General Science course at the junior secondary education level in Bangladesh. The questionnaire data were used to select participants from different demographic contexts for the detailed qualitative part of this research. In the selection process, several demographic factors (e.g., teachers' teaching experiences, school location, school type, class size and workload) were considered to ensure the "maximal variation", which helped provide a good qualitative dataset (Creswell & Plano Clark, 2007, p. 112). In this manner, we selected six teachers as the participants for the case studies. The six teachers and their associated science classes (including students) were considered as six cases. The rationale for considering multiple cases is that individual cases would share some common and contrasting characteristics that would provide an in-depth understanding of the research problem (Stake, 2005, 2006; Yin, 2003). In this paper, we present data relating to three of these cases. A snapshot of these three teachers' demographic information illustrated in Table 3 reveals that they represent a range of geographical locations (urban, semi-urban and rural), school types (co-ed and boys') with different class sizes (from 50 to 100 students) and workload (from 20 to 32 periods per week).

Table 3. Demographics of the Participant Teachers

Criteria	Sabina[#] (F)	Alam (M)	Bibhash (M)
School location	Semi-urban	Urban	Rural
School type	Co-ed	Co-ed	Boys'
Workload (periods/week)	29	20	32
Class size	53	50	100

[#]All names are pseudonyms to protect the identity of the participants.

A number of data sources, for example, interviews, lesson observations and focus group interviews were used in this case study research. Initially, we conducted a pre-lesson semi-structured interview (Patton, 2002) with each participant teacher to explore his/her perspectives of scientific literacy and the values he/she considered pertinent to scientific literacy. The pre-lesson interview, in addition, allowed us and the teacher participants to get to know each other, to develop a notion of mutual trust and build rapport (Babbie, 2011) and to make practical arrangements for observing their lessons.

Then we acted as passive observers (Mertens, 1998) of a series of classroom lessons to understand how the teachers translated their perspectives into classroom teaching. Three lessons for each teacher (Sabina, Alam and Bibhash) were observed. In order to avoid any interruption to the usual school schedule we did not request that they teach any particular content/ unit, but we did observe all the lessons for the particular unit a teacher taught. A unit may have different emphases at different times in the progress of the topic, so observation of teaching the whole unit would help understand a teacher's overall teaching approach. These observations provided rich examples of these teachers' practice in action in the classroom and were an additional data source to their verbalised practices indicated in the pre-lesson interviews. Moreover, observation of teachers' lessons helped us identify significant aspects of their teaching, which were worth further exploration during the post-lesson interview.

Each teacher was interviewed again at the end of the last observation (post-lesson interview) to gain further explanation of what happened in the classroom. These post-lesson interviews were also used to explore teachers' views on the challenging issues they encountered in their teaching for scientific literacy.

As students are an integral part of a class, their views about their class experiences are worthwhile in understanding how particular issues happened in a science class. Six students from each of the teachers' science classes comprised each of the three focus groups. The focus groups provided insights into the range of views or experiences (Morgan & Krueger, 1993) that students had about the ways science was taught in their class. In this research, focus group interviews were used as supporting data sources to understand teachers' practices in the science classes.

Data Analysis

Digitally recorded interviews and focus groups were transcribed. The interview transcripts were sent back to the participant teachers to confirm the accuracy of the transcripts in order to enhance the credibility of data (Creswell, 2007). As reading qualitative data several times gives deeper understanding about the data (Creswell, 2008), the qualitative databases (interview transcripts, lesson observation reports and focus group interview transcripts) were read several times before assigning codes to them. Using NVivo (version 8) and following Miles and Huberman (1994), a list of codes or categories were identified in the transcripts as they emerged from the data. This approach allowed for the perspectives and practices of the respondents to be identified without applying preconceptions. As this research sought respondents' perspectives and practices in the absence of a prior set of research findings from which a framework could have been constructed, it was reasonable to not impose a preconceived framework, which could impose excessive rigidity to the research.

Based on the analysis procedure as described above, detailed case reports for the participant teachers were then produced. These case reports were finally analysed applying a cross-case data analysis procedure (Stake, 2006) to understand the pattern of the themes that emerged from the cases. Concurring with Miles and Huberman (1994), it was perceived that cross-case analysis in this data analysis procedure helped achieve a deeper understanding of teacher's perspectives of scientific literacy and its underpinning values, the translation of their perspectives into classroom teaching and the issues they perceive as challenging in their teaching.

For presenting results in the following section, references to the relevant data sources are made. For example, SI1 refers to the pre-lesson interview with Sabina; BI2 refers to the post-lesson interview with Bibhash; AFG refers to the focus group interview with Alam's students, and SO1 refers to Sabina's first lesson observation, SO2 refers to Sabina's second lesson observation, and so on.

Results and Discussion

Teachers' Perspectives of Scientific Literacy

Sabina's perspectives of scientific literacy involved having the students understand the links between the science they are learning in school and their everyday life. In her words, scientific literacy is

> *... something like using science in your life. … Science can provide students with the knowledge about their health and environment. They often make decisions about food, nutrition, environmental pollution and so on. This knowledge can help them to make a decision about these everyday issues. (SI1)*

Acknowledging the linkage between school science and students' everyday life, Sabina believed that school science should have more emphasis on the science knowledge that has relevance with students' everyday life and that provides students with opportunities to become scientifically literate (SI1). This view, however, does not reflect how students' everyday life could provide contexts for science learning or dictate the content to be learned in school. Rather her perspective of scientific literacy started with learning the science content in school but with an emphasis on the content that is useful in students' everyday life. Such an emphasis, as noted previously, is considered in a Vision I-II scientific literacy (Aikenhead, 2008).

In a similar vein, Bibhash claimed that he considered teaching students about "basic cleanliness, hygiene, sanitation, and such kind of health and environment related issues" whether or not they were in the syllabus (BI1). Discussion on such health and environment related issues in science classes could provide students with knowledge to be used to make decisions about their own health and that of others, as well as about environmental matters. As noted in the OECD (2006) report, health and environment are two of the application areas of science that people encounter in their lives; therefore, such health and environment related knowledge could help students see the relevance of science with life beyond school. In addition, Bibhash also perceived the preparation of science professionals as another purpose of school science education:

> *No country can run without scientists and science professionals. Look, development level of a country is associated with the number of science professionals, such as, doctors and engineers. So, science is the key to the development of our country and thus we should encourage students to take up science related career. (BI1)*

It therefore seems that Bibhash viewed the importance of satisfying both of the major purposes of school science education (i.e., prepare scientifically literate citizenry and prepare science professionals) (Bybee & DeBoer, 1994). As discussed previously, in Bangladesh, at the junior secondary level, a single General Science curriculum caters for both of these groups of students with the expectation that the curriculum would provide all students with science knowledge to use in everyday life and encourage more students to take further studies in science, eventually leading to a science-related profession (NCTB, 1995). However, as noted previously, this balance is often violated in Bangladesh, with teachers often emphasising the need for a good foundation for the future science profession more than catering to the scientifically literate group. Such an emphasis could be considered as aligned closely with Vision I, which was observed in Alam's perspectives on scientific literacy as below.

Alam perceived that, "when a person is able to work as a science professional, I'll call him/ her a scientifically literate person" (AI1). Alam, therefore, encouraged students to consider science related professions for their career aspirations (AO1). Like many people in developing countries (Sjøberg & Schreiner, 2005), Alam perceived science as a vehicle of social and economic mobility where science professionals play the key role for this mobility. Such perceptions may persuade Alam to take more care of the minority of students who wish to pursue further studies in science, and take less care of the large majority who need a good foundation in science for being effective citizens. This notion of scientific literacy is in line with the Vision I perspective, which is somewhat at odds with the currently accepted perspective to promote scientific literacy among the science education community (Rennie, 2011).

Translation of Teachers' Perspectives into Classroom Teaching

It was apparent that irrespective of the perspectives, teachers reported in this paper had Vision I oriented teaching practice, which is argued to be failing in promoting scientific literacy (Rennie, 2011). For example, in her teaching about acids, Sabina discussed the use of acids in personal life and life beyond the personal level, such as in industries. She also discussed a global issue (acid rain) that she thought would help students to follow the media reports on acid rain (SO2). However, she did not consider a particular situation, for example, acid rain, as a context for learning about acids. As was observed, she presented acid-related content (for example, properties of acids, chemical reactions of acids with alkalis) to students and then exemplified situations or contexts (acid rain, for example) in which the content may have a role (SO2). In this manner, she used contexts as add-ons to the traditional academic content, and eventually, her teaching in action remained like Vision I practice. A reflection of this Vision I practice was also evident in her students' views, where many of them found difficulty in seeing the use in everyday life of learning about properties of acids, and the chemical reactions of acids with alkalis (SFG). Rather, students' consideration of the importance of learning about such content for their future science study and examination purpose (SFG) could be seen as an indication of Vision I practice in Sabina's science class.

In a similar vein, Bibhash's Vision I-II perspectives were translated into a Vision I practice. Most of Bibhash's discussion on salts was devoted to explaining the chemical properties of salts and associated chemical reactions and equations (BO2, BO3); such discussion on academic content would be more useful for the students wishing to study science at the upper level. His students also articulated limited use of such academic discussion in everyday life (BFG). Moreover, viewing science professionals as the key to the development of the country, he constantly encouraged students to consider science related professions for their career aspirations, and as a way of encouragement he presented students with a story of a scientist who studied in this school (BO1). Such constant encouragement could also be viewed as his emphasis on producing future science professionals.

With no exception, Alam taught science in a Vision I oriented manner. Perceiving scientific literacy as synonymous to being able to work as science professionals, Alam constantly encouraged students to consider the "prestigious" science-related professions for their career aspirations (AO1). Such encouragement was also recognised by the students in the focus group interview in that many of them recognised the science-related professions as "prestigious" and expressed their wishes to take up such professions (AFG). However, they found difficulty in articulating the use of their science learning in everyday life (AFG). This could be seen as a reflection of the lack of emphasis on the use of science in everyday life and the greater emphasis on preparing future science professionals through ascription to traditional canonical science knowledge as observed in Alam's classroom teaching practice. This Vision I practice is argued to fail to promote scientific literacy (Aikenhead, 2008; Rennie, 2011; Roberts, 2007).

Values Teachers Consider in Relation to Scientific Literacy

It was apparent that all three teachers perceived curiosity and rational thinking as the most important values for scientific literacy, but there were some differences in their perceived importance and respective teaching approach as will be discussed in the following sections. Moreover, there was evidence that teachers (Sabina and Alam) also considered open-mindedness and respect for others' opinions in science classes, but with varying notions. Teachers' cases also revealed that the least emphasis was placed on the value of intellectual honesty in science classes.

Curiosity.

Teachers perceived curiosity as important for science learning. For example, Bibhash made the case for curiosity in science learning as it prompts students to find the questions about the natural world around them that lead them to finding actions to answer the questions (BI1). With this point, Sabina added that for answering questions students would explore different resources (e.g. science books, magazines, newspapers) and extend their science knowledge, which would potentially be useful in their everyday life (SI1).

Sabina's teaching approach, however, may not promote students' curiosity. As an approach to promote this value Sabina considered asking students questions and encouraging them to ask questions as well (SI1). It seems she considered role modelling for asking questions as important if students are to perceive this as a good thing to do. However, she asked students only verification-type questions (SO1, SO3), which prompted students to answer the questions, but failed to encourage their wondering from their experiences. It may, therefore, be reasonable to consider that whilst Sabina made an attempt to promote curiosity in her students through questioning, she was not knowledgeable about the questioning that could promote students' curiosity.

Similarly, whilst Alam perceived his students as very curious (AI1) and focus group interviews with students also confirmed their curious nature, Alam's teaching approach may fail to promote students' curiosity. Alam felt that he could do so through providing thought provoking questions or statements at the beginning of a lesson and presenting stories on scientific discoveries that embrace scientists' curiosity (AI1). As observed in his teaching of gravity, he presented the famous "Newton and apple" story to represent how an incident could trigger people to wonder the reason behind the incident (AO1). When presenting the story he asked students questions; he did not, however, leave any time for students to think for themselves, and he did not give any space to them to present their thoughts and experiences (AO1) that could be useful in promoting their curiosity. It seems he asked students questions that could provoke their thinking, but was not very interested in listening to what his students thought about. Rather he took the view that just asking such questions would stimulate curiosity (AI2). This view could be considered as naive because it does not encourage students to raise questions from their experiences; this encouragement is argued to be useful for promoting curiosity. This naive view may be seen as failing to promote students' curiosity.

Whilst Bibhash perceived the importance of curiosity, he could not articulate how he considered curiosity in his teaching (BI1). Moreover, there is evidence that he did not consider students' questions in his class; even on some occasions, he stopped students from asking questions (BO2) because he viewed students' questions as responsible in creating "noise in the class" (BI2). Classroom quietness often in a form of pin-drop silence is a traditionally expected norm in Bangladesh classrooms as it is in the nearest developing country, India (Rampal, 1994). It seems that Bibhash also was concerned with maintaining classroom quietness by preventing students asking questions. His students also expressed their discomfort in asking him questions (BFG). This practice would reasonably discourage students' curiosity.

Rational thinking.

It seems that all the three teachers perceived rational thinking as an important value of science education and scientific literacy because they believed this value could help students in making justifications and rejecting unjustified things. In particular, Sabina and Bibhash extended the importance of rational thinking to challenge superstitions that are embedded in Bangladeshi society as in other developing countries (e.g., Asian Development Bank [ADB], 1998). Sabina exemplified a superstition: "if one does not say Bismillah[1] before eating something, the God produces acids [in the stomach] and the person will suffer from acidity pain" (SI1).

She made the point that science learning in school could help students form a scientific explanation of acidity. Such an explanation would challenge the superstition and it is rational thinking that would help students decide which explanation (scientific explanation or the superstition) is more plausible and fruitful to adopt. The point here is that the causes of acidity may be explained in various superstitious ways (ignoring thanks to God may be one of them) and they may vary in different local contexts. However, the power of scientific explanations (e.g., explaining acidity in scientific way) is that they are relatively universal and hence usable in different contexts. Sabina seems to have expected that rational thinking would help students to understand the power of scientific explanations in explaining phenomena.

Whilst all the teachers in this research perceived the importance of rational thinking for science learning, there was evidence that Bibhash could not articulate how he considered this value in his teaching practice. Rather he took the view that "there is no scope for any irrational thing in science; so, rational thinking will grow [automatically] with studying science" (BI1). This view may be seen as an indication of how little this value framed his teaching. A corroboration of this lack of emphasis may also be seen in his students' voice as none of them could provide any examples of how they could use rational thinking in life (BFG).

Since Alam viewed that "scientists follow [universal] systematic steps for scientific investigations", he perceived that involving students in scientific experiments would develop their rational thinking (AI1). Belief in such a myth of a single universal scientific method (Lederman, 2004), however, could lead Alam to adopt a teaching approach comprising cookbook or recipe-like hands-on activities that is very common in Bangladesh (Siddique & Rahman, 2007). In addition, Alam perceived that encouraging students to be involved in making arguments would also be useful to develop rational thinking (AI1); however, observation of three of his teaching lessons did not provide any instance of how he involved students in making arguments or how he involved students in any hands-on activity. None of his students, eventually, could provide any examples of how they could use rational thinking in life (AFG). This may also be seen as an indication of how little the value of rational thinking framed his teaching.

On the other hand, Sabina perceived that she could promote rational thinking by encouraging students to emphasise justification in making arguments and communicating ideas and thoughts (SI1). There were a number of instances in her classroom teaching reflecting her explicit encouragement of students for emphasising justification in making arguments and communicating their ideas and thoughts (SO1, SO2). Moreover, there was evidence that she encourages students to question every idea for a justification, even if the idea was provided by her (SO1). Students also expressed admiration of their teacher's constant emphasis on making justifications:

> *Benu: Madam (Sabina) always encourages us to talk rationally. When I go to say something, she will ask me to justify it. (FGS)*

These practices could be viewed as a notion of rational thinking (Corrigan & Gunstone, 2007) and may also encourage students to pose and evaluate arguments that may be seen useful for scientific literacy (NRC, 1996).

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[1] "Bismillah" is an Arabic word and the meaning is "In the name of the Allah (God)". As a religious convention of Islam, Bismillah is said as a blessing before eating food and other actions that are worthy of giving thanks to God or asking for His support.

Open-mindedness and respect for others' opinions.

Whilst Bibhash regarded open-mindedness and respect for others' opinions as two "good human qualities", he believed that his science class did not have the scope to promote these two values (BI1). He viewed scientific ideas as "proven facts" and objective in nature (BI1). This view is at odds with the subjectivity in science, suggesting that the background factors (e.g. scientists' knowledge, beliefs, commitments) influence scientific investigations in terms of choice of problems, methods of investigations, observations and interpretations of the observations (Lederman, 2007). Considering this subjectivity in science, it is argued that a portrayal of subjectivity in science might inform students that they need to be open in considering a new knowledge claim, which may, in turn, be helpful in being respectful to people's right to hold and express opinions whether they are different/ similar to their own. It may, therefore, be reasonable to consider that Bibhash's disregard about the subjectivity in science may oppose the promotion of the values of open-mindedness and respect for others' opinions in science class. This disregard may further impact on how students engage in social conversation about science related issues, and therefore, on scientific literacy.

On the other hand, Sabina and Alam perceived open-mindedness and respect for others' opinions as two important values in science education, but they have different notions of these values. Sabina perceived the value of respect for others' opinions as "very important" for Bangladeshi society, as she thought it was not very common in Bangladesh (SI1). She expected that in the long run her students would respect their counterparts' right to express views in group activities (SI1). A reflection of this expectation was found in the focus group interview with her students that they acknowledged their colleagues' right to express ideas different from them.

Whilst Alam made a case for the value of respect for others' opinions in his approach to creating mixed ability student groups, his practice built confusion among his students. In a mixed ability group, "brighter students" are involved in helping the "less able" ones, and he believed, "the weaker student may also have some distinctive things that others can learn" (AI1). This approach could be seen to be developing mutual respect among students. Students, however, raised a point that Alam was not respectful to students' alternative ideas and this may inhibit students from presenting their alternative views in the classroom. This may also build confusion among students about whether they should show respect for the right of younger and less experienced people to hold and express their views (as they are younger and less experienced than their teacher).

Intellectual honesty.

There was no evidence supporting the consideration of the value of intellectual honesty in any of these three teacher's science classes. For example, in the interviews, Sabina could not articulate her notion of intellectual honesty in science education, nor did observation of three of her classroom lessons provide any instance of her consideration of intellectual honesty. For instance, she did not explicitly (or even implicitly) encourage students to report an experiment honestly or to communicate a conclusion consistent with the data. Therefore, it would be reasonable to argue that there had been no consideration of intellectual honesty in Sabina's science classes.

Challenges to Teach for Scientific Literacy

Teachers identified issues they perceived as challenging in their teaching for scientific literacy, however, in most cases, they could not articulate how the issues affected their teaching to promote scientific literacy. Also, in many cases, they expressed their limited capacity to meet the challenges. The issues teachers perceived as challenging can be clustered into issues relating to curriculum, school, and assessment as discussed below.

Curriculum issues.

Curriculum is overloaded.

Both Sabina and Alam perceived the General Science course as overloaded with a huge amount of content to cover, and considered this as a challenge to their teaching. For example, Sabina made the point that this "overloaded" course, coupled with the exigencies of "limited time", forced her to rush through the syllabus and left little time to reflect on her teaching, resulting in lack of monitoring of students' learning (SI2). Alam extended the point that rushing through the syllabus in "35 minute" class packages restricts students' "good discussion" in groups (AI2), which he perceived to be useful in promoting students' open-mindedness and respect for others' opinions. However, neither Sabina nor Alam articulated how they could be engaged in making a decision about what is worth learning in science, to what extent students' understanding of topics needs to be scaffolded and what the students can learn on their own or may already know. Consideration of these aspects could be useful in maximising the time available for learning in science classes, rather than placing the responsibility only on the size of the syllabus and the limited time to complete it. Rather, for example, Alam's comment in this respect, "what can I do?" (AI2), reflects his incapacity to meet the challenge.

Content is mostly academic and irrelevant to students' lives.

Sabina and Bibhash observed that school science textbooks have little emphasis on content that is relevant to students' lives (SI2, BI2). This observation concurs with what is explored as the representation of scientific literacy in the science textbooks in Bangladesh (Sarkar, 2012). This overly academic nature of the content as in line with Vision I scientific literacy, may result in a reduced capacity for students to see the relevance of their school science learning in assisting them to function effectively in society (Aikenhead, 2008). This academic course may fail to meet the needs for all students as they strive to become effective citizens, and eventually, may raise the question of suitability of a common academic course for all students. This question is vital in a context like Bangladesh, as only 25% of students go on to study specialised science courses after the junior secondary level (BANBEIS, 2006).

In order to respond to this issue, wherever possible, Sabina and Bibhash discussed the possible applications of the content that they felt important for students to draw on, and explain the links between the content and the world around them (SI2 and BI2). However, the academically oriented General Science course challenged them to find the possible applications of many science contents that could help students to draw on their science knowledge and explain these links between their knowledge and its application. For example, Sabina was not confident with her content knowledge of physical sciences since this was not her academic background, and was challenged to find the applications of much of the physical sciences content (SI2). When this is the case, it raises a further question – "how do the teachers without science degrees teach this content-dominated course?". It may be reasonable to assume that they would just present the content to students in the way it is presented in the recommended textbook, which is what Sabina did for much of the physical sciences content (SI2).

Content is outdated.

In addition to the lack of relevancy of science content to students' lives, Bibhash made the point that "much of the content in science textbooks has no application in current real life issues" (BI2). For example, while perceiving the importance of contemporary IT-related knowledge for scientific literacy, he could not find any scope for teaching students about IT because there is no IT-related content in the textbooks (BI2). A centralised curriculum and prescribed textbooks guide the teaching-learning activities in Bangladesh; and therefore, the curriculum does not provide teachers with flexibility to make their own changes to it. Textbooks generally fail to embrace contemporary content and advances in science. In a textbook-dominated teaching-learning situation, this further may deter students from developing a life-long interest in science, which is also important for scientific literacy (Solomon, 2001).

School issues.

Mixed ability classes.

All three teachers expressed that their classes accommodated students with diverse academic abilities, and they found it difficult to meet the needs of all students. For example, Alam claimed that some of his students needed to revisit earlier content, but others "get bored with this and they are not willing to go through this again" (AI2). This resulted in a tension among students with different abilities.

Whilst all of the teachers perceived their mixed ability classes as a challenge to their teaching, they were not equipped to respond to this issue. Among the teachers, Sabina expressed her incapacity to respond (SI2); Bibhash proposed splitting the class into different sections based on students' ability (BI2), an approach that is at odds with the philosophy of inclusive education that Bangladesh is trying to endorse in schools (Ministry of Education, 2010).

Alam, on the other hand, took an approach to get the benefit from a mixed ability class. He categorised students based on their academic achievement and made groups with students from different categories. These mixed ability groups worked in a way that more able students acted as peer tutors for the weaker students, and weaker students showed if they have any distinctive things that others could learn (AI2). This approach to maximising the benefit of a mixed ability class may help students in developing support, mutual respect, understanding and tolerance in working in mixed ability groups.

Large class size and workload.

Since the classes of Sabina and Alam accommodated a reasonable number of students (53 and 50 students respectively), comparing this with the existing practice in Bangladesh, they did not perceive the class size as a challenge to their teaching. Bibhash, on the other hand, had about 100 students in his class; he therefore perceived this large class as a challenge to his teaching for scientific literacy (BI2). Perceiving that scientific literacy requires less emphasis on lecturing as with previous research (Goodrum, 2004), Bibhash claimed his large class forced his reliance upon lecturing, which poses a challenge to his teaching for scientific literacy (BI2).

In responding to this issue, Bibhash tried the small group approach, but the large number of students resulted in large numbers of small groups and this seemed to him unmanageable (BI2). Given the situation, he continued to rely upon lecturing and consequently the issue remained unresolved. Similarly, Bibhash expressed his incapacity to address the issue of his workload, Bibhash, on average, had a commitment of six classes per day and needed to spend time in addition to this preparing for these classes (BI2). But he perceived that he did not have sufficient "time to get prepared" as he had to run from one class to another (BI2). However, he could not articulate whether he had made an effort to maximise his time in ways that allowed for some preparation time, but rather avoided some of his responsibility with thinking that he had a heavy workload and therefore there was insufficient time for preparation.

Assessment issues.

Among the teachers, Sabina and Alam viewed the existing assessment practice as a challenge in their teaching of science. They made a common point that as practical activities were not assessed in the junior secondary education in Bangladesh, students at this level did not have access to the lab; this failure of providing lab access to students may hamper their learning and decrease their interest in science (SI2 and AI2).

In order to respond to this issue, Sabina involved students in activities that could be organised without a lab support, for example, testing acidity of household items using hand-made litmus (SO1). Alam, in contrast, viewed that "when you are learning science, it is obvious you are doing some experiments in the lab" (AI2). This view may reflect that science activities only happen in labs; this naive view may restrict him to think about activities that could be organised without a lab support.

Sabina also raised an assessment issue about using examinations prepared by an external local board as a challenge for promoting scientific literacy. These "traditional exams" did not count scientific literacy as an outcome to assess, rather these exams required rote "memorisation of a large amount of factual content" (SI2). As students' performances in these exams are used as an indicator of her teaching, she could not overlook the power of these exams. This reduced autonomy to assess one's own students, in an examination driven education system (Holbrook, 2005), made Sabina feel that this issue was beyond her capacity to address.

Concluding Remarks

In this paper, we have reported on three Bangladeshi science teachers' perspectives of scientific literacy, translation of their perspectives into classroom teaching, the values they consider in their teaching for scientific literacy, and the issues they perceive as challenging in their teaching. It is found that whilst participating teachers hold a range of perspectives of scientific literacy, in practice they demonstrated limited capacity to translate their perspectives into their classroom teaching practice. For example, Sabina's Vision I-II perspectives turned into Vision I in her teaching practice when she failed to consider a particular life situation as a context for learning science; rather she used contexts as add-ons to the academic science content. In this manner, she placed emphasis on transmitting the academic science knowledge rather than the functional science knowledge. This Vision I approach may restrict students from seeing that the science they learn in school has relevance if they are to function effectively in their everyday lives (Aikenhead, 2008). Moreover, this Vision I approach has reduced capacity to make science important to all students and results in limited development of scientific literacy for the students (Aikenhead, 2008). This approach is often linked with the decline in student interest and enrolment in specialised science courses (Aikenhead, Barton, & Chinn, 2006). It may, therefore, be reasonable to argue that this Vision I practice would enhance the decline in student enrolment in science as observed during the last decade in Bangladesh (Iqbal, 2010).

This research reveals that whilst participating teachers mostly perceived the importance of the curriculum-identified values for scientific literacy, they found it difficult to develop and implement suitable teaching approaches to promote these values. Moreover, they expressed their naive perspectives on the contemporary nature of science, for example, subjectivity in science. Teachers should not be blamed for their naive perspectives since they rarely have the opportunity to learn about the nature of science in their own studies in the context of Bangladesh (Sarkar & Gomes, 2010). As the ideas regarding the nature of science have importance to understand the ideas of scientific literacy and its underpinning values, they should be taught explicitly in science studies at different educational levels and in different teacher education programmes designed for science teachers in Bangladesh.

This research indicates that the gap between teachers' perspectives and teaching practices are perhaps due to the many challenges they felt have been placed upon them. Teachers in this research often expressed their discomfort in teaching the content-dominated General Science course in a large class. In addition, they often lamented the fact that they are obliged to prepare their students for exams that mainly assess students' memorisation of factual content knowledge. This obligation may result in an emphasis placed on memorising the factual content of science from the recommended textbooks. Teachers, therefore, may resort to using the textbooks as the authority of knowledge while students passively absorb information. Such contextual issues could be seen as contributing factors for the gap between teachers' perspectives and practices.

As noted previously, in this paper we have reported three qualitative case studies, which are part of a larger-scale study. Whilst we considered maximal variation in selecting the cases, we understand that they might not be a representative sample in

Bangladesh. However, being involved in qualitative case studies we were not keen in maintaining the representativeness, nor did we intend to claim for any generalised findings, but we were more interested in gaining an in-depth picture of teachers' perspectives, practices and challenges in relation to their teaching for promoting scientific literacy.

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