Ideas about science portrayed in the existing and proposed science curricula of grades IX-X in Bangladesh

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Abstract

This paper presents part of the findings from a comparative study on existing and proposed science curricula of grades IX-X in Bangladesh. It aims to explore relevant research to find out what ideas about science are recommended to include in school science curriculum, and then to compare the existing and proposed curricula in terms of ideas about science. This interpretive study analyzed curriculum documents and textbooks qualitatively, and the results reveal that the proposed science curriculum portrays more ideas about science compared to the existing two science curricula. However, some important ideas about science have not been portrayed well in the proposed curriculum, and therefore, there is a broad scope for improvement in communicating ideas about science.

Keywords: science curriculum, nature of scientific knowledge, textbook compare

Introduction

Secondary schools in Bangladesh have been following a differentiated science curriculum in grades IX-X. There are three streams at this level. Science stream students are expected to build a solid base of science for further study, and hence, they study three separate science units - physics, chemistry and biology. The Humanities and Business Studies students are not required to study science any further. They are expected to understand a general idea about science and its application; therefore, they study one general science unit. A new uni-track or single-track curriculum which was proposed to commence in 2006 when all students would study a common science. This new curriculum is designed for all students in order to prepare both a scientifically literate citizenry and a group of future scientists (Siddique, 2007). The enactment of the proposed curriculum has been deferred because of a movement against it. The protest has been led by a group of university science professors who have been arguing that future science students will have a weaker foundation of science as a result of studying this new curriculum. The debate on the enactment of the new curriculum led me to conduct a study on this issue in 2006-2007 as part of my Master of Education study. The study was aimed at comparing the existing and proposed curricula in order to examine whether the reform process was in the desired direction (Siddique, 2007). In this article, I report part of the findings of that study, which is focused on how ideas about science are portrayed in these curricula.

Science education reform movements have suggested what ideas or knowledge about science should be included in the curricula. For example, the Science, Technology and Society (STS) movement expects that students will have “a grasp of the epistemology and sociology of science required for understanding the dynamics at play in STS issues; for example: scientific observations are theory-laden” (Waks and Prakash, 1985, pp. 108-114, quoted in Aikenhead, 1994, p. 50). Among the recommended science content for a Science for All curriculum, two ideas - ‘the evolution of scientific knowledge’ and ‘boundaries and limitations of science’ (Fensham, 1985, p. 427) are considered important. The Scientific Literacy movement, as exemplified in the PISA study, considers knowledge about science as an important component of scientific literacy because “people often encounter situations that require some understanding of science as a process that produces knowledge and proposes explanations about the natural world" (Organisation for Economic Co-operation and Development [OECD], 2006, p. 21). There are a number of arguments found in the literature for inclusion of studies on ideas about science in science curriculum. For example, Driver, Leach, Millar and Scott (1996) and McComas, Almazroa and Clough (1998) argued that acquiring aspects of the Nature of Science (NOS) enhances the learning of traditional science content. They also asserted that NOS knowledge enhances the understanding of science; it builds up a coherent picture of science and humanizes the sciences, and thus, enhances interest in science (McComas et al., 1998). Accurate views on how science works is also vital for future citizens' political and educational decision making on socio-scientific issues (Driver et al., 1996 ; McComas et al., 1998). More recently, the science education community has articulated three main themes that are considered important for all students studying science. These three themes - the nature of scientific knowledge, methods of science (scientific inquiry) and practice of science (the scientific enterprise) - are often encompassed in one broader term like 'knowledge about science' (OECD, 2006) or 'ideas about science' (Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003). Ideas About Science (IAS) will be used in this paper to refer the above-mentioned three themes about science.

Research evidence suggests that the way science is portrayed in school has a strong influence in shaping students' views of science (Driver et al., 1996). Curriculum materials and curricular activities play an important role along with teachers in communicating ideas about science to students (McComas et al., 1998; Wieder, 2006). Hence, this paper attempts to analyze the existing and proposed science curricula of grades IX-X in Bangladesh to explore how and what ideas about science have been portrayed in these curricula. This attempt has been made to see whether the proposed science curriculum reform in Bangladesh is heading towards the desired direction.

Research design

This study involves analysis of different types of curriculum documents using a conceptual frame of IAS based on their current representation in the science education research literature. Data for this interpretive-qualitative study has been collected from Bangladesh science curriculum documents and textbooks comprising the existing and proposed curriculum documents, the existing physics, chemistry, biology and general science textbooks for grades IX-X, and guidelines for authors and publishers to publish textbooks under the proposed curriculum. The National Curriculum and Textbook Board (NCTB) in Dhaka publishes all these documents. I have analyzed the existing textbooks along with the curriculum documents because textbooks are the de-facto curricula in schools in Bangladesh. Although teachers have the main role in communicating IAS to the students, textbooks also played an important role in communicating IAS to students. Textbooks play a more important role in Bangladesh because teachers and students heavily rely on the lone textbook published by the NCTB. The qualitative exploration of ideas about science in this study was based upon:

(a) Explicit statements and/or explanations of IAS in the curriculum documents and textbooks;

(b) Implicit portrayal of IAS by the way scientific concepts are presented/discussed in the textbooks

(c) Implicit and explicit portrayal of IAS in curricular activities especially in the practical/laboratory work as portrayed in the textbook; and

(d) Emphasis given on any IAS in the assessment process as detailed in curriculum documents.

The above criteria have been used to explore IAS qualitatively and deductively based on the following conceptual framework developed from current science education literature.

Development of a conceptual framework of ideas about science

There is little consensus among philosophers and historians of science, scientists, and science educators on a specific definition and/or content of IAS. However, some consensus exists on fundamental ideas about science that are relevant and accessible to school science education (Lederman, 2004; McComas et al., 1998). Two prominent schools of thought on IAS in science education literature are Lederman (2004) and Osborne et al. (2003). Lederman (2004) and his research group describe the Nature of Science (NOS) and scientific inquiry separately while admitting that they are intimately related, and there is overlap between them. According to Lederman (2004), it is useful to conceptualize scientific inquiry as the process by which scientific knowledge is developed. On the other hand, the knowledge developed by the process has certain unavoidable characteristics, and these characteristics are commonly referred as NOS (Lederman & Lederman, 2005). Lederman (2004) and his research group used three criteria to determine what aspects of NOS can be included in science curriculum. The three criteria are (Lederman, 2004, p. 304):

1. Is knowledge of the aspect of NOS accessible to students (can they learn and understand)?
2. Is there general consensus about the aspect of NOS?
3. Is it useful to all citizens to understand the aspect of NOS?

Seven aspects of NOS that meet these criteria, and students should, therefore, be informed about: observation and inference, scientific laws and theories, science is empirically based, science necessarily involves human inference,imagination and creativity, science is a subjective and theory-laden knowledge, science is socially and culturally embedded, and scientific knowledge is tentative. These aspects of NOS have been discussed elaborately in Lederman (2004) and in Lederman & Lederman (2005), therefore, this paper does not describe them, but rather attempts to make a comparison with the ideas suggested by Osborne et al. (2003). Osborne et al. (2003) have conducted a study to determine the extent of agreement among scientists, science teachers, philosophers and sociologists of science, and science educators on IAS that should be included in school science curriculum. The study recommends nine ideas about science under three umbrella themes to include in school science curriculum. Some of the nine ideas are similar to Lederman's NOS aspect and scientific inquiry, while some differ. Moreover, two schools place variable emphases on similar ideas. Osborne et al.'s nine ideas and Lederman's NOS aspects and scientific inquiry have been presented in Table I. Following a review of similarities and differences between two schools of thought, I adapted a framework of IAS for this study by choosing ideas from these two schools of thought.

Table I: *Comparison of two sets of recommended IAS*

Broad themes about science	**Findings in Delphi Study by Osborne et al. (2003)**	**Recommended by Lederman (2004)**
Nature of Scientific Knowledge	Science and certainty	Scientific knowledge is tentative
	Historical development of scientific knowledge	Science is socially and culturally embedded
	Not suggested	Scientific laws and theories
	Not suggested	Observations and Inference
	Empirical base of science (not recommended but there was an agreement to a good extent)	Science is empirically based
	Not suggested	Science is subjective and theory-laden knowledge
	Similar to creativity under the Methods of Science theme	Science necessarily involves human inference, imagination and creativity

Methods of Science	Scientific method and critical testing	Descriptive research Correlational research Experimental research
	Diversity of scientific thinking	
	Analysis and interpretation of data	Multiple approaches and analysis
	Hypothesis and Prediction	Not emphasized
	Creativity	Science necessarily involves human inference, imagination and creativity
	Science and questioning	There may not be always be a question
Institutions and Social practices in Science	Cooperation and collaboration in the development of scientific knowledge	Not emphasized

As seen in Table I, Osborne et al. specifically recommend two ideas on the nature of scientific knowledge and implies two others, whereas Lederman recommends seven aspects of NOS. Osborne et al.s' 'science and certainty' is similar to Lederman's 'scientific knowledge is tentative'. Lederman asserts that scientific knowledge is subject to change when new evidence emerges or old evidence is reinterpreted. While agreeing with this, Osborne et al. add that much of the school science is beyond reasonable doubt. Similar is the 'historical development of scientific knowledge' and that 'science is socially and culturally embedded'. Osborne et al. assert that students should be taught the historical development of scientific knowledge explicitly to facilitate an appreciation of developments in science and to know "the ways and extent to which such developments have been affected by the demands and expectations of society at different points in history" (2003, p. 706). From this point of view, it partially corresponds with the Lederman's 'science is socially and culturally embedded', which asserts that science is affected by the society where it is practiced because the practitioners are the products of that society; social values, power structures, politics, socio-economic factors, philosophy, and religion are among the socio-cultural elements that can affect science (Lederman, 2004). However, Osborne et al.s' view differs from Lederman's because Lederman places emphasis on the current and future settings as well as the past settings emphasized by Osborne et al.. An 'empirical base of science' is recommended by Lederman, but this idea fails to meet the criteria for Osborne et al.'s recommendation by a very small margin. Osborne et al. recommend creativity under the broader theme 'methods of science', although it is similar to Lederman's 'science necessarily involves human inference, imagination and creativity'. However, Osborne et al. describe creativity in more general terms associated with the enterprise of science being carried out by humans, rather than being associated with creating explanations and/or ways in which to investigate scientific phenomena.

Osborne et al. (2003) recommends six ideas about science under the theme 'methods of science' whereas Lederman (2004) recommends teaching students about different forms of inquiry. According to Lederman, students should be informed that there is no single method or a fixed set and sequence of steps involved in science (Lederman, 2004), but rather, scientific questions guide the approach, and the approaches vary widely within and across scientific disciplines. Generally, scientific inquiry takes several forms, such as descriptive, correlational and experimental. Descriptive research derives the variables and factors important to a particular situation of interest; correlational research determines relationships among variables identified in descriptive research; and experimental research intervenes and manipulates variables to derive causal relationships among them. Experimental research often involves the development of a model, which is then tested. In contrast to Lederman's recommendation, Osborne et al.'s recommended aspects include 'scientific method and critical testing', 'analysis and interpretation of data', 'hypothesis and predictions' and 'science and questioning', which are based on the notion of experimental science. Although Osborne et al. assert that there are diverse methods of doing science; they did not elaborate on any other methods or approaches of doing science. In essence, Lederman's notion of scientific inquiry is more inclusive and comprehensive than Osborne et al.'s suggested ideas 'scientific method and critical testing' and 'diversity of scientific thinking'. Therefore, Lederman's notion of scientific inquiry will be included in the conceptual framework, instead of these two ideas suggested by Osborne et al. Three ideas - 'analysis and interpretation of data', 'hypothesis and predictions' and 'science and questioning' are embedded in Lederman's notion of inquiry; however, they can be included in the framework separately in order to place more emphasis on them in a school science curriculum. Similarly, Lederman's notion of scientific inquiry includes the scientific enterprise, but it is not explicitly dealt with. Osborne et al. emphasize the inclusion of the aspect of 'cooperation and collaboration in the development of scientific knowledge in school science by stating that scientific work is a communal and competitive activity; it is frequently of multidisciplinary and international nature. Students should be taught that scientific work is often carried out in groups, although individuals may make significant contributions. New knowledge claims are shared and peer reviewed critically before the community accepts it.

From the discussion above, it is evident that both schools of thought have some ideas in common. However, in some cases, one school of thought articulated or emphasized a particular idea in a better way than the other school did. Moreover, each of the two schools also suggests few important ideas that are different than ideas suggested by the other school. Therefore, I adapted the following framework of 'Ideas about Science' by choosing aspects from the two schools to analyze the curriculum documents in question.

Table II: *Framework of ideas about science*

Broad themes	Ideas about science
Nature of Scientific Knowledge	Scientific knowledge is tentative
	Science is socially and culturally embedded
	Scientific laws and theories
	Observations and inference
	Science is empirically based
	Science is subjective and theory-laden knowledge
	Science necessarily involves human inference, imagination and creativity
Methods of Science	Different forms of scientific inquiry - descriptive research, correlational research, experimental research
	Analysis and interpretation of data
	Hypothesis and prediction
	Science and questioning
Institutions and Social practices in science	Cooperation and collaboration in the development of scientific knowledge

Ideas about Science portrayed by three science curricula in Bangladesh

This part of the paper reports results from the qualitative analysis of curriculum documents and textbooks. The existing science curriculum for students majoring in science has a separate chapter on knowledge about science called the 'Development of Physical Science', which includes the development of physical sciences and the "method of science" (National Curriculum and Textbook Board (NCTB), 1996, p. 138). Similarly, existing general science curriculum for humanities and business students has a separate chapter on ideas about science, too. The proposed science curriculum does not include any separate chapter on this topic. However, 'Ideas about Science' are embedded in theoretical content and practical activities in all three curricula, which are discussed below.

Nature of scientific knowledge

1. Scientific knowledge is tentative: There was evidence of the tentative nature of scientific knowledge in existing science curriculum materials. For example, the following textbook excerpt shows that ideas about heat have changed over time:

Until the last part of eighteenth century, scientists thought that heat is a fine fluid named caloric. Hot matters contain more caloric and cold matters contain less … In

1778, Count Rumford proved that there is nothing like caloric in reality (Tapan, Hasan, & Choudhury, 2000, p. 155).

Similarly, the development of different concepts about the atom and the limitations of Dalton's atomic theory and Rutherford's atomic model, in addition to the evolving development of the periodic table. promotes an acceptance of the tentative nature of scientific knowledge.

There is no explicit statement regarding this aspect in the existing general science curriculum or textbook. No science content in this curriculum is presented as debatable or uncertain. Thus, science has been presented as certain knowledge.

Science knowledge has been portrayed as certain knowledge in most cases in the proposed curriculum. For example, no alternative theory or different perspective has been included in discussion of evolution or environmental pollution. Only in a few cases, the uncertainty of scientific knowledge has been portrayed. In one such case, teachers have been recommended to inform students that "there are atomic models [other than Bohr's and Rutherford's] and new ones may be formulated in future" (NCTB, 2004 a, p. 22). However, certainty of science knowledge has been portrayed as a whole in the proposed curriculum.

2. Science is socially and culturally embedded: The historical development of scientific knowledge has been emphasized in the existing science curriculum for science major students. A brief discussion of historical development of science in the first unit of the physics curriculum and textbook includes the development of science in ancient Greek and Indian civilization and in middle age Europe, the impact of industrial revolution on the development of science and the evolution of modern physical science in the nineteenth and twentieth centuries. Moreover, the brief histories of development of important scientific principles or concepts have been presented in some other units of physics, chemistry and biology textbooks. However, no discussion is found on the social and cultural influence on science in the present Bangladeshi or world contexts.

Very little emphasis has been given on the historical development of science in the existing general science curriculum. It has been mentioned that science has a big role in the development of civilization. Other than this, nothing about historical development of science or socio-cultural influence on science has been included in the curriculum or textbook.

No emphasis has been given on historical development or social and cultural embeddedness of science in the proposed science curriculum. There is no explicit content on this aspect. Moreover, the instruction to textbook authors that "there is no need to write history of [inventing the] atom, electron, proton, neutron and atomic models" (NCTB, 2004 b, p. 63) shows that this is not considered as an important idea to be included in the proposed curriculum.

3. Science is empirically based: The empirical basis of science is portrayed in existing science curriculum and textbooks for science students through the emphasis on conducting experiments and reaching conclusions from the experimental data. The textbooks, especially, show this emphasis in the description of the scientific method and in the recipe-like procedures of practical activities. For example, one of the steps of the scientific method, discussed in the physics textbook is, "accepting, rejecting or modifying the hypothesis on the basis of **experimental/empirical data**" (Tapan et al., 2000, p. 10, emphasis added). The existing general science curriculum portrays this idea about science in a similar way; the textbook emphasizes relying on empirical/experimental data for making decisions in the given examples of the scientific method and procedures of practical activities. The proposed curriculum also emphasizes relying on experimental/empirical data for making decisions in investigations and, thus, portrays the importance of empirical basis of scientific knowledge.

4. Observation and inference: Observation has been shown as an important step of the scientific method, which is discussed in the existing physics textbook, but there is nothing about inference. In the procedure for arecipe-style practical work, in the existing chemistry textbook, possible observation and inference of different qualitative experiments have been given (Hazari, 2000); but consequently, students have limited opportunities to gain inference skills from their observations. Moreover, no distinction is made anywhere in the curriculum between observation and inference. The existing general science textbook presents observation as a step of practical activities. However, nothing is found in the curriculum regarding the difference between observation and inference. The proposed curriculum does not portray the distinction between observation and inference well, though it presents the collection of data as an important step of investigation. There is no discussion on how to make observations and inferences from the observation.

5. Science necessarily involves human inference, imagination and creativity: The existing science curriculum for science major students sends negative messages to students regarding this aspect, as emphasis has been given to testing/experimenting without mentioning creativity or imagination in this process; therefore, students do not see any role of human's imagination and creativity in the recipe-style practical work. Similarly, through the recipe-style practical work, the existing general science curriculum portrays science as a human independent activity.

The proposed science curriculum has an objective "to understand the nature of science as a human activity" (NCTB, 2004 a, p. 4); and accordingly, it does portray involvement of human inference, imagination and creativity in science by giving students the freedom regarding hypothesizing, planning and conducting experiments, interpreting data and making decisions in open investigations.

Methods of science

1. Different forms of scientific inquiry: The existing physics text book noted that there is no fixed method of doing science, however, scientists' conduct scientific research in an organized and systematic way, and there is one general 'scientific method' of doing science (Tapan et al., 2000). Typical steps of the scientific method and verification type practical works show that the existing science curriculum for science students presents experimental research as the only form of science inquiry; it does not pay any attention to descriptive or correlational research. This curriculum has never mentioned that a single experiment may not be sufficient to establish a knowledge claim. The existing general science textbook describes the scientific method with an example of a farmer who conducts an experiment to know whether giving fertilizer increases the yield of the crops (Hoque, Shafiullah, Uddin, Roy, & Das, 2000). However, there are very few practical activities included in the textbook; and those that are included are recipe-style procedures; moreover, these practical activities are not to be assessed in the all-important public examination at the end of year 10. Therefore, scientific inquiry has little importance in this curriculum. The proposed curriculum does not portray different forms of scientific inquiry explicitly. However, the proposed curriculum promotes diversity in scientific thinking by introducing open investigations. There is no suggested single/fixed procedure given for the investigations. Students are supposed to identify problems, identify variables, formulate a hypothesis, plan and conduct an experiment, collect, analyze and interpret data in order to reach conclusions. It is likely that different students will carry out an investigation in different ways. It is also likely that procedures will be given in new textbooks; in this case, there will certainly be different procedures in different textbooks, because a number of textbooks are supposed to be published by the NCTB and other publishers (NCTB, 2004 b). Moreover, different investigations other than the experimental method have been included in the curriculum; the proposed curriculum, therefore, promotes diversity in doing science.

2. Analysis and interpretation of data: The existing science textbooks curriculum for students in the science track have provided students with the analysis and interpretation of data in details of the procedures of practical works. Therefore, this curriculum provides students limited opportunities to gain skills of analyzing and interpreting data.

The existing general science curriculum has not included analysis and interpretation of data in practical works. Therefore this curriculum too gives students little scope to gain knowledge and skills in analyzing and interpreting data.

The proposed curriculum gives students a good opportunity to acquire skills in analyzing and interpreting data because analyzing and interpreting data is shown as an important step in investigation; however,no procedure is given for this, so students are supposed to analyze and interpret data themselves. Moreover, students are likely to take analyzing and interpreting data seriously because these skills are supposed to be assessed in School Based Assessment.

3. Hypothesis and prediction: The hypothesis has been presented as an important step of the scientific method in the existing science curriculum for the science students, but the textbooks have not included hypothesizing in the given procedure. This may create confusion in students' minds regarding the importance of hypothesizing in science. The existing general science curriculum also shows hypothesizing as an important step of scientific method, but does not include it in the practical work. The proposed curriculum presents hypothesizing as an important element of the investigation or practical work, and this aspect is recommended to be assessed in the examination. Therefore, the proposed curriculum emphasizes hypothesizing as an important aspect of doing science.

Institutions and social practices in Science

1. Co-operation and collaboration in the development of scientific knowledge: This idea about science has been portrayed negatively in the existing science student curriculum. The curriculum and the textbooks presented contributions of individual scientists in physical science and biology; this may portray science as an individual's endeavor. Group work, which could have portrayed science as a collaborative endeavor, has not been promoted. The existing curriculum and the textbooks for science students do not show that scientists work in groups, and they cooperate and collaborate in doing science.

The existing general science curriculum for humanities and business students gives students an impression that science is an individual's endeavor by mentioning individual scientist's inventions. Moreover, working as a group has not been promoted anywhere. On the other hand, the proposed curriculum has emphasized cooperation and collaboration in science by suggesting students' work in groups for investigations. Unlike the existing two curricula, the curriculum does not emphasize individual scientist's work.

None of the three curricula have any discussion on three ideas - science and questioning or the subjectivity and theory laden-ness of scientific knowledge or the distinction between laws and theories. The ideas about science portrayed (or not portrayed) and how they are portrayed in three curricula is presented briefly in Table III.

Table III: *Ideas about Science portrayed (or not portrayed) in three curricula*

Broad themes about Science	**Ideas about science**	**Existing science curriculum**		**Proposed science curriculum**
		for science students	**For others**	
Nature of Scientific Knowledge	Scientific knowledge is tentative	Portrays scientific knowledge as tentative	Portrays science as certain knowledge	Portrays science as certain knowledge
	Science is socially and culturally embedded	Emphasizes historical development strongly, but socio-cultural influence on science is neglected	Emphasizes very weakly	Does not portray at all
	Science is empirically based	Portrays in the scientific method and practical activities	Portrays in the scientific method and practical activities	Portrays in the investigation
	Observation and inference	Portrays incompletely in practical works	Portrays incompletely in practical works	Does not portray well
	Scientific laws and theories	Does not differentiate	Does not differentiate	Does not differentiate
	Science is subjective and theory-laden knowledge	Does not mention at all	Does not mention at all	Does not mention at all
	Science necessarily involves human inference, imagination and creativity	Portrays negatively	Portrays negatively	Portrays in investigation
Methods of Science	Different forms of scientific inquiry	The experimental method is the only form of inquiry	Does not give importance to scientific inquiry	Implicitly promotes diversity in doing science
	Analysis and interpretation of	Gives limited scope in order to	Gives little scope in order to be	Gives good scope in order

	data	be skilled in analyzing and interpreting data	skilled in analyzing and interpreting data	to be skilled in analyzing and interpreting data
	Hypothesis and Prediction	Has a confusing portrayal	Has a confusing portrayal	Strongly emphasizes hypothesis
	Science and questioning	Tells us nothing regarding this aspect	Tells us nothing regarding this aspect	Tells us nothing regarding this aspect
Institutions and social practices in Science	Cooperation and collaboration in the development of scientific knowledge	Portrays negatively	Portrays negatively	Promotes this aspect

Discussion and conclusion

All three science curricula portrayed different ideas about science in different ways, which have been discussed in the previous sections and summarized in Table III. The existing science curriculum for science focus students portrays the three IAS well: (i) Science is socially and culturally embedded; (ii) Scientific knowledge is tentative and (iii) Science is empirically based. This curriculum does not effectively portray other IAS. Ideas like the ‘different forms of scientific inquiry’, ‘human inference, imagination and creativity in science’, ‘science and questioning’ and ‘co-operation and collaboration in the development of scientific knowledge’ humanize the scientific endeavor and convey a great adventure, thus enhancing students’ interest in science (McComas et al., 1998). The incomplete and/or negative portrayal of these ideas, therefore, may discourage creative and co-operative students from studying science at later stages. Students are likely to face difficulties in understanding a coherent picture of science due to the absence of any discussion regarding the differences between observation and inference and the differences between laws and theories. The above discussion suggests that the existing curriculum for science students does not work well with the suggestions from current literature about communicating ideas about science.

As discussed earlier, the existing general science curriculum portrays most of the ideas about science suggested by Lederman (2004) and Osborne et al. (2003) incompletely and negatively. Thus, the students of humanities and business studies concentrations are likely to get an incomplete and inaccurate picture of science. Moreover, they will not have more formal science education in future, and therefore, science and decision making in science related matters will remain as an uncomfortable territory in their lives.

Although the proposed curriculum does not include an explicit discussion on IAS, some of the ideas in the ideas are portrayed well in the curriculum. These are: (i) science is empirically based, (ii) analysis and interpretation of data, (iii) hypothesis and prediction, (iv) diversity in doing science, (v) science necessarily involves human inference, imagination and creativity and (vi) co-operation and collaboration in the development of scientific knowledge. These aspects are portrayed in a manner consistent with the recommendation of Lederman (2004) and Osborne et al. (2003). The proposed curriculum presents science as certain knowledge, but it does not explain why science is certain. This is inconsistent with the recommendation of Lederman (2004) and Osborne et al. (2003); because, although much of the science knowledge in school curriculum is well-established and beyond a reasonable doubt, it is subject to change in the future given new evidence or new interpretations of old evidence. The proposed science curriculum does not portray other ideas about science well.

The above findings suggest that the process of reforming science education in Bangladesh has been heading towards the desired direction in terms of portrayal of IAS. However, some important ideas have not been portrayed well in the curriculum. In line with the views of science educators (Driver et al., 1996 ; McComas et al., 1998), I firmly believe that acceptable views on how science works is vital to: (a) enhance the learning of science content, (b) enhance the understanding of science, (c) enhance interest in science and appreciate science as a human endeavor, (d) help people use scientific knowledge in everyday life and (e) enhance future citizens' political and educational decision making. The way science is portrayed in school science curricula contributes significantly in shaping students' views about science. Therefore, the proposed curriculum should include explicit content on how science works and it should clarify ideas about science. The ideas that 'scientific knowledge is tentative', 'science is socially and culturally embedded', scientific laws and theories, 'science is subjective and theory-laden knowledge', observation and inference, and questioning should be clarified in the curriculum. Also, an important idea to be included explicitly in the proposed curriculum is that scientific inquiry may take place in the forms of descriptive, correlational or experimental research. An open investigation in the proposed curriculum creates a great opportunity to communicate IAS to students. However, inclusion of IAS in the curriculum or textbooks will not make any difference unless they are communicated well in the classroom. Teachers are the responsible for communicating IAS to students accurately; therefore, teachers should be trained on what and how they will communicate ideas about science to students.

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