DEVELOPING STUDENTS' UNDERSTANDING OF THE TENTATIVENESS OF SCIENCE THROUGH ESPECIALLY DESIGNED HANDS-ON ACTIVITY

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ABSTRACT

This article reports an in-depth discussion and learning of the four students of class eight about the tentativeness of science. It also highlights the ways in which students understand the nature of science (NOS) through especially designed hands-on activity. The distinction between this activity and others was that this activity explicitly focused on one aspect the NOS: Science is tentative. I worked with four boys of mixed abilities from a private English medium school of Pakistan. I taught them outside their real classroom. The teaching was done twice a week for seven weeks using specially designed hands-on activity. The teaching approach used is influenced by the philosophy of Costructivism that learners have to construct their own knowledge by tying up the new information with their prior experiences.

INTRODUCTION AND BACKGROUND OF CONTEXT

In the context of Pakistan, majority of the science teachers and teacher educators mostly provide scientific information to their students rather than helping them to understand science, and how scientific theories emerge. That is why students do not believe that, they themselves can construct their own theories by interacting with hands-on minds-on activities and discussing their ideas with each other. Therefore, this article aims to see: to what extent and in what ways specially designed hands-on activities develop students' understanding about the tentativeness of science. The important characteristic of the specially designed hands-on activity is that they explicitly focused on one aspects of the NOS. Halai (1999) notes, “hands-on activities are helpful, but there is a need for more explicit discussion of the concepts of NOS as they relate to each activity” (p. 62).

Science demands children to develop an awareness of their surroundings and environment, so that they can connect the practical activities done in class to their real-life situations. For example, science teachers enable students to discover the natural phenomena by using their senses. They create a conducive environment where students are able to interact with concrete material and discuss it with each other. When I reflect on my past experiences, I feel that I treated students as empty vessels. I fed facts to students from science textbooks and expected them to reproduce these facts in the form of mid-term and annual examinations.

Similarly, in the middle schools of Pakistan, science textbook is considered a source of all knowledge. Science is considered as factual knowledge which students have to memorize for the examination. For example, if we asked students to draw the shape of any leaf of a tree on paper, they drew the same shape, which was in their textbook. They did not think of drawing the diagram of a leaf from their own environment. This shows that teachers have inscribed the images of textbooks on their minds.

There is no link between the classroom teaching and the daily lives of students. Students believe that science prevails in the classroom and textbook only. Teachers do not engage students in meaningful activities. They neither provide them with the opportunities to use their real-life experiences to develop interest and curiosity, nor are the students given a thorough understanding of the underlying reasons for the facts. Harwell (2000) has cited Stiner, who believes that “students are frequently turned off to science because they are often required to perform learning activities they perceive as ‘not connected’ to an ‘evidential experimental base’ that makes sense to them” (p. 236). Brickhouse, Dagher, Shipman and Letts (2000, p. 11) have cited Driver et al. (1996) identified five rationales for teaching about the NOS. These are:

1. A utilitarian argument is an understanding of the NOS, which is necessary if people are to make sense of the science and manage the technological objects and processes, they encounter in everyday life.
2. A democratic argument is an understanding of the NOS, which is necessary if people are to make sense of sociocentric issues and participate in the decision-making process.
3. A cultural argument is an understanding of NOS, which is necessary in order to appreciate science as a major element of contemporary culture.
4. A moral argument is an understanding of NOS, which can help to develop awareness of NOS, and in particular the norms of scientific community, embodying moral commitments that are of general value.
5. A science learning argument is an understanding of NOS, which supports successful learning of the science content.

OBJECTIVES & PURPSE OF THE STUDY

- The key purpose of this study was to explore ways of effective use of specially designed hands-on activities to develop students' understanding of NOS.
- This study also intends to identify the constraints and challenges associated in teaching through such hands-on activities.
- The major objective of this study was to understand how specially designed hands-on activity helps to develop students' understanding of nature of science (NOS).

RESEARCH QUESTION

In what ways and to what extent do especially design hands-on activity develops middle school students' understanding about the nature of science (tentativeness of science)?

RESEARCH METHODOLOGY

Multiple methods of data collection were used in the study such as: semistructured interviews, observations, field notes, reflections of students and researchers' own reflections. This research is presented in the form of a case study. Stake (1995) notes, case studies are the preferred method of research when *'how'* or *'why'* questions are asked. The benefit of using a case study approach is that it allows the researcher to examine the various dimensions of an event or situation. Research in a case study involves an in-depth description of the factors affecting the participants and how they function, including cultural norms and traditions, values and ingrained attitudes and motives. The case study approach looks specifically at an individual or small participant pool and draws conclusions based only on a particular participant's work. It encourages the researcher to get involved in the lives of the participants and becomes a participant observer, thereby gaining a deeper understanding of the culture, behavior, actions and ways the participants interact with each other.

To conduct this study, I selected four students of class eight. The rationale for selecting this grade was that researcher felt comfortable to working with students of this level because researcher has been teaching science to the same grade students to his school. Researcher selected a small sample because he wanted an in-depth understanding of teaching and learning process about the NOS. Besides, researcher thought it was a convenient number of students to work with keeping in mind the time frame and development of hands-on activities. Miles and Huberman (1994) suggest, "qualitative researchers usually work with small samples of people, nested in their context and studied in depth" (p. 27). The nature of the study was to focus on hands-on activities and observe their role in changing the beliefs of students regarding tentativeness of science

DATA ANALYSIS PROCEDURE

Researcher went through all the collected data and prepared notes. Researcher reflected on students' written response sheets to find patterns in their understanding of the NOS and inquiry process. Researcher maintained a reflective dairy to note his personal reactions towards students learning.

Because researcher had audio-recorded the interviews and teaching sessions, He could play again and again their interviews or lesson. Frankel and Wallen (1983,) affirm that" the tapes may be replayed several times for continued study and analysis" (p.401). Transcriptions of the recorded interviews were made. This was a time-consuming, but crucial facet of data analysis. Researcher found it very helpful as he could get in depth interpretations, which he may have missed during the interview. While transcribing, researcher was mentally analyzing the findings. He was also trying to identifying themes and making categories. On the basis of the coded data, researcher was able to write analytical memos on a weekly basis to make an organized report, as evidence of the study. These analytical memos guided researcher to proceed further towards findings. The data was organized and coded according to the themes emerging from the data. In the data analysis stage, the focus was only on learning of students about tentativeness of science through especially designed hands-on activity (cube activity).

STUDENTS' VIEWS OF THE TENTATIVENESS OF SCIENCE

I would like to give a brief overview of the four students' understanding about the tentativeness of science. They said that science is a branch of knowledge, which is gained through lectures of teachers and memorizing the textbook. Science has no connection with real life. It is useful only for engineers, doctors and scientists. Science always creates confusions and conflicts in religious beliefs. They emphasized that science should obey the values of religion and cultural myths. For instance, they said that in the *Holy Quran*, it was clearly mentioned that there is an existence of *jinn* and *fairies* then why does science not believe that! This statement reflects students' superficial approach of teaching and learning science. They thought that science is bound with cultural and religious myths. It is a traditional way of thinking because many scientists were hanged in the history of science because of this belief. We need to introduce the concept of NOS in schools and colleges if we want to develop openness towards the concept of science in the minds of students. On concluding the study, several favorable changes were evident in the participants' views of the aspects of NOS.

INTERVENTION PHASE: PLANNING & TEACHING

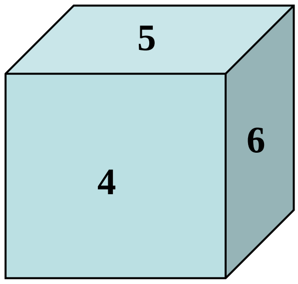
The crucial part of teaching through hands-on activities is the idea that children should reflect on their own experiences. This could involve children considering questions at different stages of hands-on activities that the teacher may ask, such as: What do you think will happen and why? Can you explain why you say so? Why do you think this evidence is stronger than that? Such questions helped students to see a connection between formal (classroom) and informal (home and play ground) learning situations, which is important to develop students' understanding of the tentativeness of science. Secondly, proper organization of activities also made a difference in developing students' learning. I tried to present the material of activities in appropriate ways, as mentioned below:

- Clear, written instructions, guiding questions regarding the activity and social skills were shared.
- Structured discussions in group, but started from individual observations and thinking.
- Demonstrations and manipulation of hands-on material so that students could move from first hand experience into constructing new knowledge of abstract concepts of the NOS.
- I regularly summed up the discussions of the students to enable them to see their own thought process.
- I encouraged students to write their reflections about the lesson at the end of the sessions to evaluate my teaching and their learning.

CUBE ACTIVITY

Figure 1

A cube made out of stiff paper.



Note: The Directions for making cube are given on p. 28. This activity has been modified from McComas (1998). *The nature of science in science education: Rationales and strategies.* Dordrecht: Kluwer Academic Publishers

DESCRIPTION OF THE ACTIVITY

The major focus of this activity was to make the students understand that observation helps to search for patterns and much of the knowledge of our surrounding is empirically based.

Engage: To find out students' current understanding regarding NOS and to motivate participants I asked the following questions:

1. How do scientists work?
2. How do scientists solve their problems?

Through brainstorming I collected students' responses.

Explore: This stage consisted of the following steps:

Step one: Researcher encouraged students to sit around the table (knee to knee, and eye to eye). After that asked them to observe certain social skills (listen to each other, respect each others' ideas, take turns, manipulate the materials carefully) and gave guided instructions.

Step two: Researcher placed the cube in the center of the table and told the students to observe it and predict what was written on the bottom of the cube. I encouraged them to support their answers with evidence and also include an explanation of how they reached that answer.

Step three: Researcher asked them to share their findings with other students in the group-discussion. Each student in the group verbalized his observations, which researcher recorded on the data recorder.

Explain: Then I asked the participants to share their findings. I facilitated the discussion by making connections between their experiences with the cube and the key elements of their discussion. I wanted them to behave like scientists who make their explanations public, through presentations and professional meetings and accept critique from other scientists.

Evaluate to evaluate their understanding of some of the aspects of NOS, I asked them to design a similar cube in pairs and try to teach the other pair.

DETAILED DISCUSSION OF THE IMPLEMENTATION OF THE ACTIVITY

I started to brainstorm with the students using the question: How do scientists work? Here I am going to share a few responses I got from the participants, which helped me to understand their perceptions about scientists' work. The participants think that:

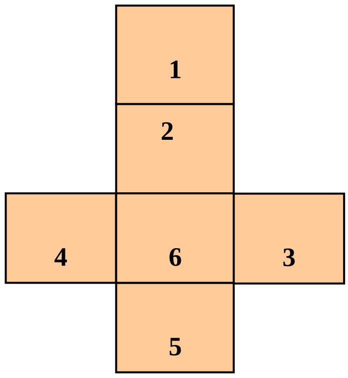
- Scientists observe things and then think.
- Scientists use the five senses to observe, they perform experiments in the laboratory and invent machines.
- Scientists collect information from books of other scientists.
- Scientists ask themselves many questions.

While probing, I found that the students had a very limited perception about observation and experiment. They thought that just seeing things was 'observation' whereas 'experiment' was a process of making machines and engines.

After wrapping-up the discussion I placed the numbered cube on the table. The number at the bottom of cube was 2, which was glued to the surface of the table so that students could not lift or move it to see the number.

Figure 2

Mystery cube with exposed numbers



I asked students to infer the hidden number by using inquiry skills. Students observed the exposed sides of the cube and recorded the data. On the basis of the known data, they inferred the number. I encouraged them to support their conclusion through the use of evidence. They all presented the same evidence, which I had in my mind. I was surprised when I compared the students' ideas with my own ideas, that is, when I was studying at the same level, and I found a big gap between my understanding and theirs. The students' analysis was much more sophisticated than mine. This experience helped me learn that we should not underestimate children. I also concluded that our past experiences and beliefs affect our process of teaching and learning. The new generation has rich experiences and understanding about the natural world because of modern technology and the media. That is why my research participants created more patterns than I did. I had two kinds of patterns but they created four patterns. The patterns which they shared were:

1. The exposed sides are 1,3, 4, 5 and 6, and because 2 is missing from the sequence so it is at the bottom.
2. First three even numbered sides were shaded and the first two odd numbered sides were white but one number was missing, that is 2, which

should therefore be at the bottom.

3. The third pattern discussed was resemblance of the cube to a *dice* which has six sides with the first six natural numbers written on each side. Hence, there should be first six natural numbers on the cube but 2 was missing. Therefore, the number on the bottom had to be 2.
4. They developed the fourth pattern when I gave some clues (Can you think about opposite sides having another pattern?). The pattern is that opposite sides add up to 7, that is, 1+6; 3+4? +5+2

During the interview, three students said that learning of science happens only in the classroom. There was no opportunity to learn science at home or in the playground. The third pattern, which they made, was related to their daily life activities and the skill of finding patterns was an important element of the inquiry approach and the nature of science. After I received their input on the third pattern, I helped them to reflect on their previous argument and to compare both experiences. This made them realize that science could be learned from daily life experiences if we observe things carefully. They also said that imagination could play an important role in making patterns.

Initially they were reluctant to predict the number and give an explanation to support their argument. They felt uncomfortable making mistakes. I encouraged them to make mistakes, and try to learn from those mistakes. To reduce their tension, I made a mistake and then confessed to having made that mistake. Students were arguing about the definition of a cube and they asked me how many sides there should be in a cube. I told them that there might be eight sides. They accepted my answer because they trusted me. They felt that I knew the answers to all the questions. After two minutes I apologized and confessed my mistake. This made a difference in developing openness among students. They reflected on this experience and appreciated my frankness. Then they started to share their experiences more openly.

They were very curious to open the cube or lift it up. By the end of the teaching sessions, they were asking me whether the number at the bottom was 2 or something else. From this experience I concluded two things: first, that young learners are keen to interact with concrete materials, and that they have an innate curiosity. Second, that they are keen to find one right answer. Shouqat for instance agreed that they emphasized right answers and definitions of the scientific terms rather than the process. Children's' reactions to the hands-on activities and their thoughts on what they had learned about the five aspects of NOS were obtained from their reflections at the end of each lesson. Some of their thoughts have been narrated below.

CUBE ACTIVITY AND STUDENTS' LEARNING ABOUT NOS

People have many ways of knowing about their world including scientific knowledge, cultural knowledge, and religious knowledge. Science differs from these ways of knowledges in various ways: Science is a system of exploring the natural universe through data collected by observation, experimentation and peer justification. Based on the collected data, theories are advanced to explain and account for observation. This aspect is known as the empirical nature of science. Scientists formulate and test their explanations of nature using observations, experiments and theoretical models. However scientific ideas can also be informed from indirect observation. Theories and models can be developed by observing and inference. In traditional classrooms science teachers do not try to teach abstract science concepts in an appropriate way that is why students remain in doubt about the existence of abstract things. Only lectures or logical statements cannot give conceptual understanding of the abstract concepts of NOS. We need to teach abstract topics through concrete materials so that students can move from concrete to abstract concepts. In cube activity students worked like scientists. They constructed explanations on the basis of observations and challenged each other's ideas. They tried to support their explanations through evidence

The cube activity helped students to understand the importance of their observation skills and their past experiences. They felt that past experience and existing theories of science helped them to predict an unknown number and to describe the observations in a scientific way. They also felt that the cube activity was an effective source of providing an opportunity to justify the explanations and by sharing them with other colleagues. In short, the cube activity helped them to enrich the hands-on experiences with the use of minds-on strategies. They said that the generalization of abstract ideas from concrete experiences was a difficult task except for the peer support.

All four participants said that observation was an important element in collecting data for developing conclusions about natural phenomena. Their existing understanding and daily life experiences helped them to draw conclusions from the observations. For example, they said that the past experience of interaction with natural numbers and mathematical skills helped them to develop patterns, which led them to predict the unknown bottom number of the cube, which was 2.

This activity also encouraged students to learn some inquiry skills, which started from observation of a concrete object or a critical question. For instance, students started their inquiry through the observation of the cube with a question like: How do scientists work? Students were able to recognize the relationship between explanation and evidence, but their level of understanding was superficial. They said that their previous knowledge and theories helped them to explain why they said that the hidden number was 2. They said nothing comes from zero. To initiate any kind of scientific exploration, they needed to start from an observation of a concrete material that is why physical senses of human being are called the doors of scientific knowledge.

From this experience, I found that students love to observe and manipulate concrete objects. Therefore, I would suggest that for students in the early grades (class one to eight), the emphasize should be given on gaining experience with natural and social phenomena and on enjoying science. Abstractions of all kinds can gradually make their appearance as students mature and develop an ability to handle explanations that are complex and abstract. That does not mean, however, that abstraction should be ignored altogether in the early grades. By gaining lot of experience doing science, becoming more sophisticated in conducting investigations, and explaining their findings, students will gather a set of concrete experiences on which they can draw to reflect on the process. More importantly students should be encouraged to ask over and over, "How do we know that is true?"

ADVANTAGES OF SPECIALLY DESIGNED HANDS-ON ACTIVITY

The study illustrated that hands-on activities enhanced children's understanding of NOS and content knowledge as well. For instance, they said that the magical activity strengthened their understanding of multiple concepts.

SCIENCE FOR ALL

Hands-on activities have the potential to involve all students in learning regardless of their abilities. The research participants of this study had different socio-economic backgrounds and their learning abilities were also different from each other. I identified their abilities from the pre-interview and their progress reports, I got from the assistant head teacher. I found that all four participants were involved equally in learning, but the level of participation and questioning was different. I think it was not due to the intellectual difference but due to the communication skills, which depended on the context they belonged to.

ENHANCED ABILITY TO ASK QUESTIONS

Hands-on activities helped the students to open all gateways (five senses) for critical observation. There were some discrepancies (students observed unexpected events which were inconsistent to their predictions) in activities, which motivated them to ask questions, and question is the key to learning science. A good question is the starting point of an inquiry as well as NOS. A great scientist does not know answers of all the questions but he knows how to ask a good question. Good questions help to clarify confusions and conflicts while ambiguous questions cultivate confusions.

ENHANCED PHYSICAL AND INTELLECTUAL ABILITY

In many situations children's weaknesses in using the science process skills, proved to restrict their ability to show their understanding of particular concepts. Especially, making predictions without a familiar context was particularly difficult and emphasized the importance of concrete experiences for children with intellectual problems. Secondly, while manipulating the concrete materials students learned to use their physical senses appropriately.

COMMON ISSUES OF SPECIALLY DESIGNED HANDS-ON ACTIVITIES

Despite this positive impact, nonetheless, many significant issues emerged from the study, which need to be addressed in order to ensure successful implementation of especially designed hands-on activities, and conceptual understanding of the different aspects of the NOS. These challenges are:

TIME CONSTRAINTS

Planning and designing of appropriate hands-on activity is a time-consuming stage. Hands-on activities in the science classroom do not produce a learning environment automatically. We must plan the activities in accordance with the needs of contexts and level of students. We should provide clear instructions and use appropriate language. Keeping in mind all these issues it seems difficult to prepare hands-on activities for a large class, but it is not impossible. If we are committed to our students, we could manage to do that by giving extra time and taking help from children as well. Students have a zest to help teachers and they want to demonstrate their creativity if teachers encourage them to do that.

The possibility of students being distracted by using hands-on activity is always there. Conflicts may arise any time. As I mentioned above while working on the cube activity students started to discuss and ask questions about the definition of a cube, a square and a rectangle. This distraction could be useful if a teacher knows how to direct them towards the learning point otherwise it could be time consuming. I confronted this situation while teaching the footprint activity. Students' frequent questions distracted me. Therefore, teachers need to develop the skills of facilitating learning through hands-on activities effectively.

LACK OF SUPPORTIVE ENVIRONMENT

The noisy classroom (because of the old fans), frequent visits of teachers were also a factor, that reduced the effectiveness of the activities I used in the class. Students asked me in their reflections to change the classroom but all the classrooms were engaged. From this experience, I learned that a peaceful environment is an important factor in enhancing the learning about NOS through hands-on inquiry.

DIFFICULT TO COVER THE WHOLE SYLLABUS

This experience made me ask these questions: Is it possible to cover the whole syllabus by following this way of teaching? Will the administration of the school allow me to teach science for one hour? All the stakeholders encouraged good results through memorization rather than understanding. Keeping in view the current situation of the school and the beliefs of the stakeholders, I had to complete the syllabus otherwise they would not allow me to teach through hands-on activities. The only possibility to resolve this issue was that I teach through hands-on activities once a week. In the remaining five days I concentrated more on the syllabus and I encouraged students to memorize concepts with understanding.

CONCLUSION

The study illustrated that hands-on minds-on activities helps students to develop their understanding about nature of science in general and tentativeness of science in particular. Post interview data revealed us that the conceptual understanding of students about tentativeness of science had been enhanced to a large extent. They explicitly said that science is tentative, changeable, not permanent and that was the aim of this research study. Some background knowledge of students about NOS is important to develop scientific thinking regarding tentativeness of science. American Association for the advancement of science [AAAS] 2000. Scientific knowledge can and does change. This is one of the fundamental tenets of the nature of science (NOS). It is crucial to teach NOS through hands-on activities, incorporating them with historical and daily life examples, if we want to develop students' understanding about NOS. In this research, I felt that in teaching NOS, one of the most difficult tasks that a science teacher confronts, is trying to motivate the students to take an active interest in abstract and complex aspects of NOS. One obvious method of overcoming this dilemma is to provide examples, analogies of the relevant aspects of NOS, and giving opportunities for group discussions. Hence, to impact the scenario of science teaching and learning in Pakistani schools, we need to accept the challenge of teaching NOS explicitly through hands-on/minds-on activities. Davis cited (1989) in

RECOMMENDATIONS

If we want our children to have a good grasp of science and inquiry skills, we need to help teachers and policy makers to understand NOS especially tentativeness f science. Science teachers of class eight, no doubt will feel that their domestic problems and academic load (especially in the government sector) will not permit them to incorporate NOS with the help of hands-on activities, but my study has shown that even if you conduct such an activity once in a week it can enhance the conceptual understanding of NOS that leads students to become scientists in later stages. We just need to use very simple activities to proceed the discussion, but we need to be more focused on the different aspects of NOS. It has also revealed that in some situations hands-on activities cannot make a difference. I am not advocating students to confine themselves to hands-on materials but they should go beyond the concrete stage. They should have the opportunity to make meanings from the empirical observations through their own interpretations.

PILOTING THE ACTIVITIES

One of the ways of teaching tentativeness of science effectively through hands-on activities is to test them in an informal setting before teaching them in the actual classroom. I had experience of piloting some of the specially designed hands-on activities at the intervention stage and found it to be useful. It helped me to identify the issues related to the activities beforehand and therefore, I addressed those issues before the actual teaching. This practice enhanced my confidence as well.

AVAILABILITY OF TWO CONSECUTIVE PERIODS

The experience of teaching four students with specially designed hands-on activities helped me to know that hands-on activities are time consuming. It needs at least 60 minutes to teach the concepts of NOS through hands-on activities. That is why science teachers should have the opportunity of taking two consecutive periods, twice in a week.

COOPERATION RATHER THAN COMPETITION

Successful learning is connected to the environment in which learning occurs. One of the important features of the learning environment is to develop a cooperative culture where pupils are open to sharing their ideas and experiences with each other. Hodson and Hodson (1998) have cited Johnson and Johnson (1985) who believe that well- managed cooperative learning experiences can promote higher levels of achievement than do competitive and individualistic learning for both children, with or without learning difficulties, of all ages and across all subjects. A sense of cooperation among students develops confidence in taking risks to critique others and to be critiqued, which eventually leads them towards democratic learning. Helping students work in groups facilitates hands-on learning and directly engages students in the process of science. Studying science requires learning skills associated with communication and cooperation to develop an understanding of NOS. Ossont (1993) who found that cooperative learning is very useful in class eight because it offers the chance to combine academics and socialization elements that are equally important.

CONFLICT IS NECESSARY FOR THE CONSTRUCTION OF NEW KNOWLEDGE

Learning starts from conflicts, but it has different implications on different age levels of students**.** The earlier a child learns to deal with conflicts the better the outcome will be in future life. Hence, I suggest, that the teachers of class eight should introduce some challenging tasks so that students are confronted with conflicts and challenges. Students can learn many things while addressing the challenges, as they would try to resolve the conflicts through the use of problem-solving approaches. Hodson (2001) has cited Lee (1997) notes, “When students’ cultural experiences are in conflict with scientific practices, when they are forced to choose between the two worlds, or when they are told to ignore their cultural values…[they] may avoid learning science” (p. 13).

TEXTBOOKS SHOULD BE RE-STRUCTURED

Most science teachers want to follow the textbook especially in the government sector, that is why the textbooks should be enriched by adding the concepts of NOS relevant to the level of the students. Although it is a big recommendation, it could be possible to make it feasible at classroom level by negotiating with the stakeholders of the school. As I mentioned earlier, the concept of NOS consists in our national curriculum of science, but it is missing in the textbooks.

THINK BIG START SMALL

It is unrealistic to expect all students or teachers to become competent philosophers or historians of science. We should have realistic expectations but high aims in introducing concepts of NOS in a large classroom. I will start by introducing the simple aspects of NOS and then gradually move towards more abstract aspects. Matthews (1990) has stressed this point saying: “Since it takes historians and philosophers of science, decades of study to derive generalizations about NOS from the historical evidence, it is unrealistic to expect teachers or students to develop profound understandings from necessarily limited exposure to the world of science” (p. 330).

BALANCE BETWEEN CONTENT, PROCESS AND NOS

To clarify the importance of each area I would like to use an analogy. Content and process make the structure and functions of the body, and NOS is the spirit of that which gives life to the body. We cannot deny the importance of any of the above-mentioned concepts. We should try to have a balance among the content, processes and NOS while teaching science. In the traditional paradigm both the process and NOS were ignored while content was given complete exposure. In contrast, in the present practices the entire emphasis is being given to the process while ignoring NOS and content.

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