Students' Scientific Epistemology: 'Source of Knowledge' – a Comparison between two Biology Lessons in a high-school classroom

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Abstract. This paper investigates the construction of one of the components (the source of science knowledge) of scientific epistemology present in a high-school biology classroom, from the classroom discourse. Focusing on the enacted scientific epistemologies of the student, we analyzed field notes obtained from two sessions of classroom lessons to identify various tenors in the discourse and infer the source of knowledge in the students' minds. The science curriculum is being taught using the THINK cycle (not discussed in this paper) and it centered on engaging the student with the teacher taking the role of the facilitator of both small-group and whole-class discussion. The analysis of this initial stage indicated that the students were involved in the classroom interactions, and there was a spread of the teacher and student involvement and the students used various sources of knowledge through the two sessions in the Biology classroom.

Keywords: Source of knowledge, scientific epistemology, biology classroom, classroom discourse

Introduction

Epistemology is an area of philosophy concerned with the nature and justification of human knowledge. Hofer and Pintrich (1997) referred to epistemological beliefs as the individuals' conceptions about the nature of knowledge and the nature or process of knowing. The study of epistemological beliefs is critical to education. The source of science knowledge is one of the components of scientific epistemological beliefs (Schommer, 1994; Hofer, 2001; Elder, 2002). This study compares the source of science knowledge as it is constructed in a high-school biology classroom in Singapore.

Students' beliefs about scientific inquiry are shaped by how science has been taught to them, textbook descriptions, scientific articles and Internet materials. Bell & Linn (2002) define beliefs to broadly include images of the nature of science, the purposes and activities of scientists, the goals of science courses, and the learning strategies appropriate for understanding scientific material. Research shows that students' scientific epistemological beliefs play an essential role in determining their learning orientations towards science (Edmondson & Novak, 1993) and the ways of organizing cognitive structures of scientific knowledge (Tsai, 1998, 1999). Sinatra (2001) suggested that understanding the role of learners' beliefs about the nature of knowledge, or epistemological beliefs, is important in the learning process, thus students' beliefs about the nature of science and scientific knowledge are considered an important part of their science education (Lederman, 1992). Likewise, Hofer (2001) stated that epistemological perspectives are related to learning in various ways, like influencing reasoning and judgment, and thus have implications for teaching. Research also indicates that epistemological beliefs affect the degree to which individuals (Schommer, 1994) actively engage in learning, persist in difficult tasks, comprehend written material and cope with ill structured domains. All these areas suggest that epistemological beliefs may either help or hinder learning. Edler (2002) found out that students' epistemological beliefs in science reflected both mature and naïve understandings with students endorsing relatively sophisticated statements about the changing nature of science. One major component of scientific epistemology, from the above literature, is source of science knowledge which this paper will look into.

Many of the studies in the literature talk about using the questionnaire and/or interviews to determine epistemology, however some have mentioned that for the measurement of epistemology, an instrument is alone not enough and that there is a need for other qualitative methods to triangulate data (Comerford, Busk & William,2000). As classroom discourse is an indication of what is happening in the classroom and how and what the members of the classroom are doing, it can be analyzed to shed new light on student epistemology. To our knowledge, this has not been explored extensively in the literature. In this study, classroom discourse is explored to develop a deeper understanding of how beliefs are communicated in the classroom environment. Halliday & Hasan (1985) talks about the function of language as the way people use their language. As part of the science classroom, this study is interested in the pragmatic or practical use of language and how knowledge is constructed in a classroom discourse. The function of interest to this study is the information talking and we use what Halliday & Hasan (1985) describe as the tenor of discourse which is concerned with the personal relationships involved: who is taking part.

In terms of source of knowledge, researchers have been categorizing it in a dualistic manner. They categorize it as either self or authority (Baxter Magolda, 1992; King & Kitchener, 1994; Schommer, 1990). This paper attempts to look at finer dimensions of the source of knowledge by looking at the enacted epistemologies through the field notes obtained from classroom observations.

In evaluating classroom discourse, attempt is made to look at the characteristics of scientific epistemology: source of knowledge and attempts to derive finer classifications. Our main project seeks to study the transformations of the students' scientific epistemological beliefs as they move from a traditional mode of instruction to a more student-centred practice. The purpose of this paper is to look into how student classroom discourse or utterances can be used to infer evidence for this aspect of scientific epistemology, the enacted belief about 'the source of science knowledge'.

Method

In this study, the aspect of scientific epistemology (source of knowledge) is explored among the students as they undergo a new integrated science curriculum. The utterances of the students from a series of lessons are used to identify the 'source of science knowledge' using discourse analysis. As part of the bigger study, various sources of data such as field notes, audio recordings of group discussion, student artifacts and interviews were obtained. However, for this paper, only the utterances from the field notes are analyzed to infer about the 'source of science knowledge'. To analyse a classroom discourse, the field is first described, then different sections within the text are created using the tenor, and within each of these tenors the various 'sources of knowledge' are identified.

A teaching programme designed to facilitate a problem-based curriculum was implemented with twenty-three 15-year-old students at a Junior College in Singapore. These students are from different secondary schools who have applied and have been accepted into the first year of a Junior College (equivalent to a senior high school in the US) offering a four year integrated programme in which they pursue various subjects including Chemistry, Physics and Biology. The curriculum is broad-based, inter-disciplinary using a variety of teaching methods including problem-based learning. The students in this programme are generally of above average abilities. These students have studied science for 6 years (science only starts in primary 3) and have been exposed to various methods of traditional teaching such as teacher-centred lessons and laboratory activities. The school's science department conducted their science teaching and learning using the THINK cycle. The THINK cycle is a 5-stage instructional model to problem solving. THINK refers to Trigger, Harness, Investigate, Network and Know. As part of the programme for the sciences (Physics, Chemistry and Biology), the students are grouped and are posed with an authentic problem, the 'Trigger' and they will solve this as they exist in groups. They each have a tablet PC and they have wireless communication in the classroom and labs. The Trigger (T) phase provides authentic problems, in the Harness (H) and Investigate (I) phase they are actively involved before they constructively embark on a series of investigations in the Investigate (I) phase and are cooperative in the Networking (N) phase and they display the knowledge gained in the Know (K) phase. In all these phases their participation is intentional and thus the THINK phases allow for students to be engaged in meaningful learning. Students typically worked in groups of four or five to investigate the problem posed in the trigger phase and develop their own explanations for the situation. The teacher was intended to be more of a guide and facilitator and less of an information provider. During most of the THINK cycles, the students accessed the internet for their information in the topic, while the teacher acted as a guide and monitored them through the cycle.

In the context of this study, all the science lessons are grouped into various sessions which is made up of a series of lessons during which the students work on a particular task and it may be made up of two or more lessons depending on the nature of the task. In this paper, two sessions were analyzed to identify evidences for 'source of science knowledge'. The first session consisted of two lessons during which the students learnt the parts of a microscope and then observed their cheek cells and onion cells through the microscope. During the first lesson, the teacher first elicited through questioning, the prior knowledge of the students in the topic of cells. The students then identified the parts of a microscope and then learnt how to prepare slides and view them through the microscope. During the second lesson they continued the earlier lesson, by preparing the cheek cells first and then staining them before they observed them through the microscope and later, they did this similarly for onion cells. Finally the students did a mini-THINK cycle in which they explored the characteristics of animal and plant cell and shared their findings with the class.

The second session consisted of four lessons during which the students learnt about cell structure. During the first lesson, the various groups are given various triggers, which are scenarios of diseases. During this lesson the teacher also gets the students to document their conversation by asking them to form MSN chat groups where they have the members of their group and the teacher. During the second lesson, students worked in their groups for their presentation the following lesson. During this lesson the teacher spent time with each group to clarify doubts and make sure they are on the right track. The third and fourth lessons were presentations by the various groups followed by the teacher emphasizing important aspects from the group's presentation.

The field notes for the two lessons were first divided into different sections depending on the tenor, the personal relationship involved. When similar tenors were occurring for continued period of time they were all grouped as one chunk. For example, when there was a teacher-student class discussion going on, there were many teacher-student interactions going on. However in the analysis they were all grouped as one *Tr-St* tenor as long as the same student was involved. By using tenor, the field notes were divided into smaller segments in which the different 'sources of knowledge' were identified.

Results and Discussion

Table 1 below shows the number and percentage of the various tenors during the two sessions of THINK cycles.

Table 1: Number and percentage of various tenors

Type of tenor	Number (Percentage) of occurrence for Session 1	Number (Percentage) of occurrence for Session 2
Teacher-Student Tenor	23 (50%)	49 (50%)
Teacher-Student- Student Tenor	5 (11%)	12 (12%)
Student-Student Tenor	18 (39%)	38 (38%)

Though session 1 had only two lessons as compared with four lessons in session 2, it can be seen from Table 1 that the distribution of the tenors is similar. The teacher- student (Tr- St) tenor in both sessions occupies around 50% of the lesson, showing the dominance of this tenor in the whole lesson. Though the pedagogy was planned for a student-centered lesson, teacher talk still occupies 50% of the session. Though opportunities are provided for group discussions and class presentations, this occupies only about 50% of the lesson because during the group discussions, the teacher consistently monitors the group by walking around the class and thus enters into conversations with the students. As the teacher says during the lesson, the teacher is involved in "an intellectual discussion" with the students to make sure they are on track as they go about the THINK cycle. This shows the involvement of the teacher in the lesson.

To look into the source of knowledge during the various tenors, each tenor is re-looked into to identify the source of knowledge and then categorized. A summary of the source of knowledge for the two sessions is shown in Table 2 below.

Table 2: Source of knowledge for two sessions

Source of Knowledge	Number (Percentage) of occurrence for Session 1	Number (Percentage) of occurrence for Session 2
Explaining	7 (15%)	24 (24%)
Demonstration	3 (7%)	0
Questioning		
- Recap	3 (7%)	4 (4%)
- Student initiated	1 (2%)	17 (17%)
-Teacher initiated	3 (7%)	13 (13%)
Prior Knowledge	4 (9%)	6 (6%)
Experiential	6 (13%)	0
Interaction of Peers	8 (17%)	12 (12%)

Presentation	2 (4%)	7 (7%)
Text/Notes	4 (9%)	0
Internet	5 (11%)	16 (16%)

Though literature classifies the source of knowledge in a dualistic manner, using the above coding, we attempt to classify the source as further into teacher, student and media, which are then further divided into finer categories. The finer categories are shown in the figure below.

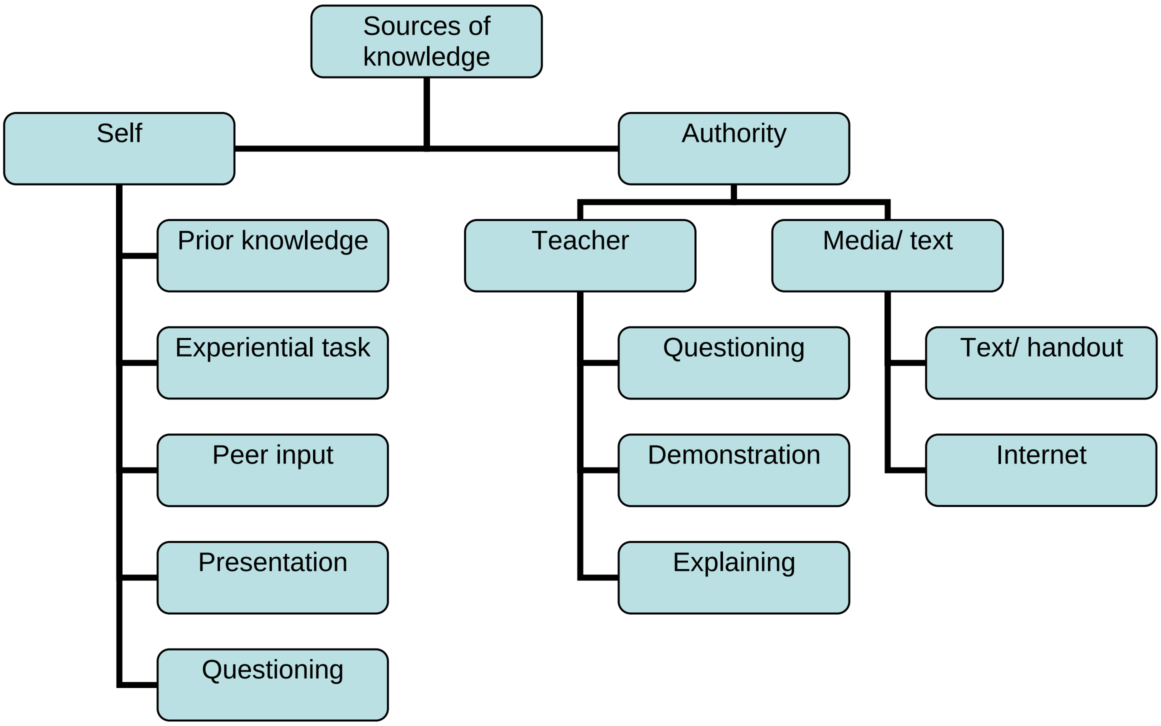

Figure 1 Sources of knowledge

Figure 1 shows that there are more distinct sources of knowledge under the student category thus implying that there are more sources that are derived from the student in these lessons. On summarizing the information from Table 2 into the three categories (self, teacher and media) of source of knowledge, it can be seen that in both sessions the student accounts for a higher percentage in terms of sources of knowledge.

Table 3: Source of knowledge within the three categories

Source of Knowledge	**Session 1**	**Session 2**

Teacher	29 %	37 %
Student	52 %	46 %
Media/ text	20 %	16 %

The THINK pedagogy that the teachers are following for the science curriculum thus enables more opportunities to tap the student as a source of knowledge. As in the Investigate phase, the Networking phase of the THINK cycle intentionally allowed for students to be engaged in meaningful learning thus resulting in the higher percentage in the students' source of knowledge category. However, the THINK pedagogy was conceived with the idea where the teacher is to act as a guide and mentor and less as an information provider. However, as the teachers wanted to be sure that the students were on the right track and also for the fact that they had 'time constraint' where they had to complete a specific topic in a certain number of periods, they were a source of knowledge for more than 25% of the lesson. For a session to become more student-centered, this reliance on teacher can be reduced further.

In terms of the media/text as a source of knowledge, both sessions have quite a similar percentage (20% and 16%). However, in session 2 there was a greater reliance on internet and as no notes were provided by the teacher there was no text involved. The greater reliance on the Internet could be due to the fact that the students were given a whole lesson to prepare for their presentation in session 2 and thus they had more time to surf the internet for information and also in session 2, the students used MSN to communicate in addition to the face-to-face conversations. In the MSN conversations which were also analysed similar to the field notes, the students shared various websites and information they found on the organelle they were working on. For the source of knowledge, by looking at these two lessons, there is a higher percentage of the source from the student (52% and 46%) as compared to the teacher (29% and 37%) a shown in Table 3. This emphasizes that by posing the authentic problem in this problem-solving pedagogy, the students derive a greater percentage of source of knowledge from 'self' than from 'authority'.

Conclusion

By examining classroom discourse, this study shows that we can look at how students enact their scientific epistemology for the component of "source of science" knowledge. Finer categories such as teacher, text/media and self are obtained which can be further categorized into demonstration, questioning, prior knowledge, experiential task, interaction of peers and others as shown in Figure 1. This study thus moves the study of scientific epistemology one step ahead by looking at the enacted epistemologies rather than the perceived epistemologies which were derived from questionnaires or interviews from various studies in the literature (Schommer, 1994; Edler, 2002; Tsai, 1998, 1999). Both biology sessions prove that giving students authentic problems to solve in order to learn a topic provides greater opportunity for students to use 'self' as a source of knowledge.

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Acknowledgements

This paper is based on research funded by the Learning Sciences Lab.