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Using Argumentation as a Strategy of Promotion of Talking Science in a Physics Classroom: What Are Some of the Challenges?

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This paper discusses lessons learnt from a bigger study which investigates teaching approaches that could be employed to address the problem of classrooms that are dominated by teacher-centered approaches with minimal students' talk. The purpose of this paper is to establish the feasibility of success when argumentation is introduced as a part of learning physics in Lesotho. This study draws its theoretical framework from socio-cultural theory of learning. A three-staged teaching sequence whose main purpose was to promote talking was implemented at a government-controlled high school in Maseru. An important finding is that introduction of argumentation as a strategy of introducing learner-centered approaches in science classrooms proved to be beneficial. The paper highlights that the greatest challenge to the introduction of argumentation in Lesotho is related to changing the tradition that science teachers have adopted.

Keywords: talking science, argumentation, teaching strategies

Introduction

The learning and teaching of science in many developing countries faces challenges caused by the learning and teaching taking place within the second language environment (Rollnick, 2000). In Lesotho, these challenges are compounded by the fact that students at secondary education level are used to the tradition of seating down and watching the teacher. There are research reports that show that typical physics lessons in Lesotho are dominated by chalk and talk (Qhobela & Moru, 2009). In such cases, there is little students' talk except when students are asked a question or requested to ask, by the teacher. Among the reasons that teachers raise for opting for chalk and talk approach is the external pressure to produce "good results" at the end of the secondary level. This means that any suggestion for improvement in teaching practice must meet this condition. The problem though is that the pass rate of all the science subjects' combinations has remained around 20% for years now. There is, therefore, a need for different teaching strategies. This paper argues that the learner-centered approaches that emphasis argumentation can better address this problem.

This paper discusses results drawn from a bigger study which investigates teaching approaches that could address the problem stated above. The purpose of this paper is to establish the feasibility of success when argumentation is introduced as part of teaching physics in Lesotho. The paper addresses the following research questions: (1) Can introduction of argumentation in Lesotho secondary education level schools help towards

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improving the success rate?; and (2) What are the challenges of teaching argumentation at secondary education level in Lesotho?

Background

Lesotho is a small and landlocked Southern African country which has faced a variety of educational challenges since its independence from UK (the United Kingdom) in 1966. Its secondary education takes the format of a structure of 3 + 2. That is, it takes five years and is divided into two levels, namely, the LJC (Lesotho Junior Certificate) and the COSC (Cambridge Overseas School Certificate). The LJC takes the first three years (Forms A, B and C) at the end of which students write external examinations. The COSC takes the last two years (Forms D and E) and similarly at the end of the two years students write external examinations. At COSC level, science is an optional subject. Most schools tend to offer two science subjects: biology (5090) and physical science (5124) which is a combination of physics and chemistry. A few schools are beginning to offer pure physics (5054) and chemistry (5070). These options are designed and examined by the University of Cambridge in UK.

Many high schools offering science subjects at both junior and senior secondary levels lack laboratories, equipment and chemicals. Most schools are characterized by empty libraries, overcrowded classrooms and laboratories, a lack of other teaching/learning facilities, such as computers and teaching aids and a severe shortage of science teachers (Lerotholi, 2001). As a result, it is highly likely that some students successfully complete secondary education without even having done basic school science experiments. The only resource students are likely to have is a prescribed textbook and the notes provided by teachers. Anecdotal evidence suggests that teachers depend on the prescribed textbooks and one or two books they bought when they themselves were students at the tertiary level.

Theoretical Perspective

This study draws its theoretical framework from two interrelated socio-cultural perspectives of learning. The first perspective is that learning occurs in social activities. The second is that learning science is a discursive and cultural process (Leach & Scott, 2003). Classroom settings informed by these perspectives give students opportunities to practice the social language of the aspired community. Classroom talk in these settings is not restricted to only responding to questions asked by the teacher or students. There is evidence that talk in a science classroom is beneficial in a number of ways (Swain, Monk, & Johnson, 1999; Rivard & Straw, 2000). Swain et al. (1999) showed that different opportunities for talk in the chemistry class offered students different benefits. Similarly, Rivard and Straw (2000) concluded that talk impacted on their subjects positively in sharing, clarifying and distributing knowledge. Their conclusion is in conformity with Lemke's (1982, p. 264) argument that, "Science classroom talk can be seen as serving two major functions: The coordination and control of what we do and when the control and development of our use of the 'thematic systems' of science".

Talking science must be associated with how scientific knowledge is generated. Scientists do not merely make claims and such claims be accepted as scientific knowledge. They must convince other members of the community that their findings can be taken as new contributions to scientific knowledge (Ford & Forman, 1996). Talking science, particularly between peers, in science classrooms must therefore comprise of students being able or helped to argue a viewpoint, making and describing an observation and reaching some inter-subjectivity. Toulmin's (1958) framework of argumentation is a systematic representation of how talking in science classrooms should be made. According to this representation, argumentation comprises using available data to make claims. In the process of making claims, warrants and backings are given to support the claim. Further, rebuttals showing when the claims may not be acceptable are also provided. Recently, science and mathematics educators have used Toulmin's framework to unpack the importance of talk in classrooms (Erduran, Simon, & Osborne, 2004). Critical to this study is the conclusion that argumentation increases understanding of scientific concepts.

The use of argumentation has attracted attention within the mathematics and science education sector toward: understanding its effect on learning (Jimenez-Aleixandre, Rodriguez, & Duschl, 2000), pre-service teachers' uptake of classroom talk (Erduran, Ardac, & Yakmaci-Guxel, 2006), and in analysing students' written work (Kelly & Takao, 2002). In an empirical study, Erduran et al. (2004) used TAP (Toulmin's argument pattern) as an indicator of quality and quantity of argumentation in classroom discourse and managed to develop a tool for tracing improvements in argumentation over time. Jimenez-Aleixandre et al. (2000) explored trends in the classroom discourse between ninth grade learners over a period of two weeks. Their results show that, to a large extent, the positive effect of argumentation has on the learning of scientific concepts. This means that encouraging use of argumentation in the classroom promotes effective learning of science. Rojas-Drummond and Zapata (2004) and De Vries, Lund, and Baker (2002) provided further support to the view that argumentation provides humans with a powerful thinking tool. The conclusions drawn by Lubben, Sadeck, Scholtz, and Braund (2009) and Scholtz, Braund, Hodges, Koopman, and Lubben (2008), however, regarding the impact of African culture on the ability of students to engage in argumentation cannot be over looked. Lubben et al. (2009) related lower levels of argumentation in students who came from poor schools in the Republic of South Africa to African cultural background in which argumentation may be hardly practiced.

Methodology

A three-staged teaching sequence whose main purpose was to promote talking in a physics classroom was implemented in 2009. The study introduced 45 Form D students, at a government-controlled high school in Maseru, to basic argumentation approach adapted from the Toulmin's framework. Unlike in other schools where students are offered a combination of physics and chemistry science subjects, students participating in this study are registered for a pure physics subject.

In the first stage of the teaching sequence, students were asked to discuss their ideas in relation to the number of forces acting on a body in circular motion. At this stage, no formal introduction of argumentation was done. In the second stage, an argumentation approach was introduced. Students were encouraged to include the following whenever they discuss a scientific phenomenon: What do I know about this topic?; What will happen? Why?; and What conclusion can one draw from all these issues. Students were then given two activities that encouraged argumentation. In the third stage, students were given an activity which further provided opportunity for argumentation. In 2010, students were given a test comprised of two questions extracted from the 2002 physical science (5124) May/June examination and the 2003 physics (5054) May/June exanimation. The major factor that influenced the choice of these two questions was the issues of reliability and validity of the test questions.

Data was collected through audio recording and students' written test scripts. Students, working in groups of four members on average, were asked to voluntarily audio record their discussions. Two groups recorded most of their discussions. In order to respond to the first research question, data analysis was done in two phases. In the first phase, talk from audio recording was transcribed and analyzed. The analysis included consideration of the following sub-stages: (1) Is there a justification in an utterance?; (2) What justification is it?; and (3) Is there any indication of physics concepts leant? The second phase included analysis of test scores and relating these test responses to individual students' talk. In order to respond to the second research question, features of students' talk enabling or disabling, argumentation are identified and related to teaching strategies.

Results

Analysis of data shows a positive effect of the intervention in terms of both argumentation and performance as it will be reflected as follows.

Argumentation

As indicated above, argumentation of scientific concepts was introduced in three stages. Episode 1 is an extract of a discussion, from the first stage, among four students: Thabang, Thabiso, Likeleli and Likhapha. The students were determining the number of forces acting on the shoe, as it rotates around a fixed point. This episode highlights the nature of discussions students had to be throughout the activity and shows most of the forces that students identified and discussed.

Episode 1

(The following applies to all episodes: Names = pseudonyms; … = inaudible; bold = translation from Sesotho; and ( ) = comment)

1. Likeleli: I think friction is there, gravitational, what is that circui (thinking)? Yes! I do not know how to say it.

2. Likhapha: Let me tell you, it keeps, you see it keeps, it is kept.

3. Thabang: Let us go!!

4. Likhapha: It is kept, it is kept to a fixed position toward, ehh no towards ehh centre, because the… here.

5. Thabang: Yes!! Talk.

6. Likhapha: And you see! I think it is centripetal.

7. Thabang: How many are they?

8. Likeleli: The question is how many forces are acting and supporting why.

9. Thabang: Yes!

10. Likeleli: You have two.

11. Thabang: You mentioned two mention two; friction, pull or push and what? Is it coulomb?

12. Likeleli: (interrupting) friction, pull or push, centripetal.

13. Thabang: Is it centripetal or coulomb force?

14. Likhapha: What?

15. Thabang: The force between the ehh the legs ehh.

16. Thabiso: Coulomb force is is is does not act towards the centre.

17. Likeleli: This one that, this one.

18. Thabang: That is it will be, it will be coulomb force and centripetal force, and we will have pull and push force.

Are students in this episode attempting to justify claims and has that process contributed in any way towards the learning of a scientific concept? There is no justification of views provided by any of the students. Argumentation possibilities were missed in this episode. For instance, Thabiso in turn 16 made a suggestion that needed some explanations of what coulomb force is and what applies it. This failure of debate issues can be alluded to a number of factors. For example, one contributing factor could be that students were not used to argumentation. The other factor could be the assumption that the communicator makes that his/her audience understand what is meant. Students in this episode maybe assuming that they are contributing to this process of naming forces, and thus, their agreements, according to Edwards (1997), may be mostly mutual knowledge.

Students have mentioned five forces in this episode (friction, gravitational force, centripetal, coulomb and pull or push). The reasoning they used in naming these forces is the Newtonian concept of action-reaction pair of forces. For instance, in turn 11, Thabang mentions friction and pull/push, and in turn 18, he mentions coulomb and centripetal forces. These forces are intended to connote the action-reaction pairs. During the class discussions, Thabang reported that they agreed that there are six forces and the sixth one was normal force which acts in the opposite direction to the gravitational force. However, some physics concepts are conceptually problematic. For example, the concept of coulomb force is conceptually incorrect. The idea was discussed during class discussions and the final agreement was that there are at least five forces. Although there is no argumentation and some physics concepts are incorrect, Episode 1 highlights the potential, often missed in traditional strategies of teaching, of argumentation in science classrooms where facilities may be very scares. The fact that students discussed ideas had positive impacts on the learning process. However, since they do not demand justification from others poses challenges to the teaching process.

The next stage of the teaching sequence included introducing argumentation using the strategy explained above. Episode 2 is a discussion between four students: Thabang, Likeleli, Thabiso and Thabo. They are trying to decide if they agree or disagree with a given story.

Episode 2

1. Thabang: … you see! Who says I can stop it?

2. Likeleli: (Same time) Likhapha.

3. Thabang: (Continuing) Likhapha, by applying a… in a different direction, you understand?, but I can stop it (reading), how?, by applying an opposite force on the… side.

4. Thabo: Opposite force (thinking) oh! You mean that opposite force will be the opposing force?

5. Thabiso: Yes! Opposing force (saying after Thabo).

6. Thabang: …You know if you have opposing force, if you apply… if they are the same there will be no motion.

7. Thabiso: There will be no motion.

8. Thabang: But if the applied force is greater than the opposing force there will be a motion, but acceleration will…

9. Thabiso: But, then here there is no mention of… there might be a force applied.

10. Thabang: But, the statement said "But I can stop it" meaning that when… how can you stop it?… you cannot stop

it if you, for example this ruler, you are applying a force here, if I apply a vertical moment it will still move but if I apply the same force that is applied on the other side yes it will…

Students have provided justifications of their views in this episode. For instance, in turn 4, Thabo makes a suggestion, and in turn 6, Thabang makes a justification that supports Thabo's view. Thabo is claiming that "… an opposite force on the other side" will keep the ruler from turning. The justification is that when an action force and "opposing force" are equal they result in no motion. The conclusion that students were about to make in this episode is that the ruler will be balanced by the two forces and thus agree with the communicators in the story.

There are conceptual problems with some of the physics concepts students mentioned in Episode 2. In addition, the language used to refer to the principle of moments is problematic. For instance, in turn 6, Thabang says, "… if they are the same there will be no motion". At least, two words are used without accuracy in this utterance, namely, "same" and "motion". The word "same" is used to refer to "equal". That is, Thabang claims that when the action and reaction forces are equal the ruler will not move. This claim is conceptually problematic mainly, because Thabang does not consider the effect of distance from the pivot. The word "motion" is used to imply "turning". Again, in turn 10, Thabang refers to "moments" and "forces" without really drawing the differences. This type of talk is characteristic of everyday talk where precision and accuracy are often compromised by communicators (Moje, 1995). Two factors may have contributed towards this. Firstly, this may be explained by the fact that the principle of moments was introduced after this discussion, and therefore, the talk took a form of exploratory (Qhobela & Rollnick, 2010). Secondly, the effect of using a second language in learning and teaching may be suspected.

The third stage of the teaching sequence involved students' discussing questions that required application of the concept of principle of moments. Episode 3 is an extract of a discussion among four students: Thabang, Likeleli, Thabiso and Thabo. They are determining how they can find the mass of an apple using the concept of principle of moments.

Episode 3

1. Likeleli: We put that mass here, then the apple, we will compare the mass of the apple and that one…

2. Thabang: You know mass, this mass, isn't it? We would have done this!! Then we say, isn't it? This mass of the apple, we put 100 g here, we put the apple here isn't it? Then, we take this mass as our force that pushes this thing downwards.

3. Likeleli: 100 g.

4. Thabang: 100 g, we assume this load of 100 g to be a force that pushes this thing downward this side, isn't it? We want to balance it with the apple. Then, we want to see if this thing did, this thing. It might be like this, it might be like this, let's see how it will be. Then, we should say FX, meaning that, we might say our force, this one, we do not know, that will be mass of the apple, we take it to force is that so? We multiply it by distance, distances are equal (silence). But it will, let me see… I mean F_1X_1 equals, or do we use clockwise moments here? (silence).

5. Thabo: (taking at the same time) Clockwise moments?…

6. Thabang: Yes!!, they are moments, you see… about a pivot. We have to say clockwise.

7. Thabo: Clockwise is equal to anticlockwise.

8. Thabang: Equal to anticlockwise moment (coughs). So, we will have (silence) our clockwise moment will be, it

will be, let us take it to be this 100 g, then say 100 g moment isn't it.

In Episode 3, students made efforts to justify their opinions. For example, in turn 1, Likeleli makes a suggestion and gives a justification of how it helps them. In turn 2, Thabang makes a suggestion of what they should do and justifies the role of the mass, and in turn 4, he justifies how their set-up will be helpful.

It is evident from the talk that students leant important aspects of application of the principle of moments. From the scenario they considered, they would find mass of the apple to be 100 g, since they placed the mass and the apple at equal distances from the pivot. During the whole class discussion, a similar presentation was made by a different group. Class discussion of that presentation gave the teacher an opportunity to discuss a design highlighted in Episode 3 as a specific case and to show what the general case will be (i.e., distances not equal). An aspect of talking in Episode 3 that comes to the fore, which may have contributed positively to the process of the argumentation, is the fact that students used Sesotho. This should not be surprising, because it is now a common understanding that one's language can be a more powerful psychological tool than the second language.

This study, therefore, shows increasing attempts of argumentation by students as the teaching sequence advances. In the first stage, students did not provide justification of their views, but in the subsequent stages, they started giving some justifications.

Performance

Effectiveness of argumentation in science classrooms will be measured by its ability to lead to possible satisfactory performance of students in external examinations, and thus, provide some assurance to teachers who maybe persuaded to adopt the strategy. The test described in the methodology section was written by 39 students. The general performance is highlighted in Figure 1.

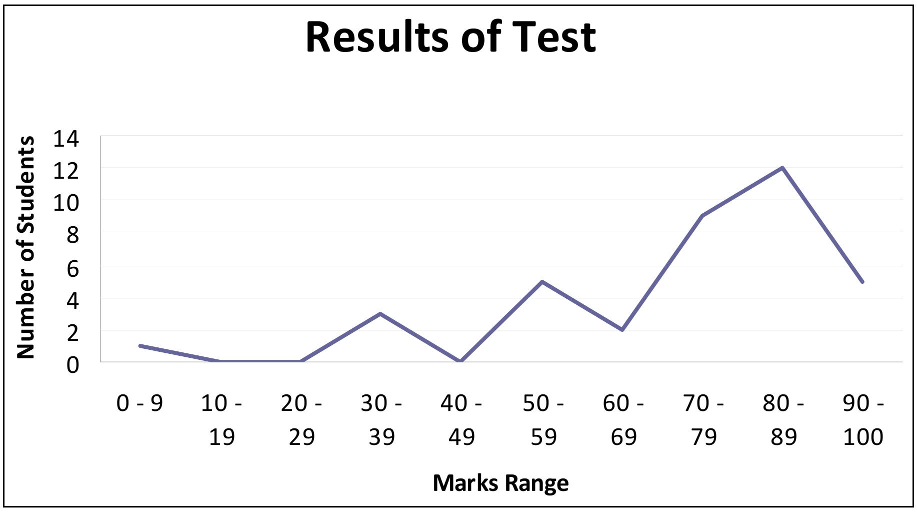
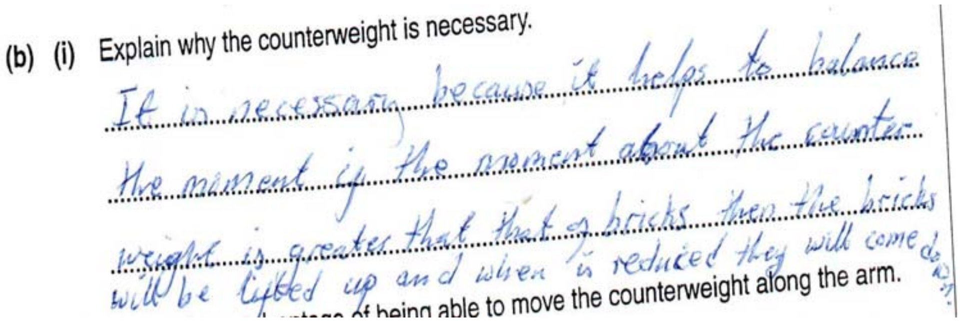


Figure 1. Performance of students.

These results show a graph skewed to the right. While avoiding misrepresentation of this graph, the results indicate possibility of satisfactory success rate.

It is important to reflect on how students involved in the above episodes responded to the question that needed argumentation. In general, the responses of students can be grouped into two categories. The first category is of students who justified their reasoning. Thabiso responded to this question as shown in Figure 2.

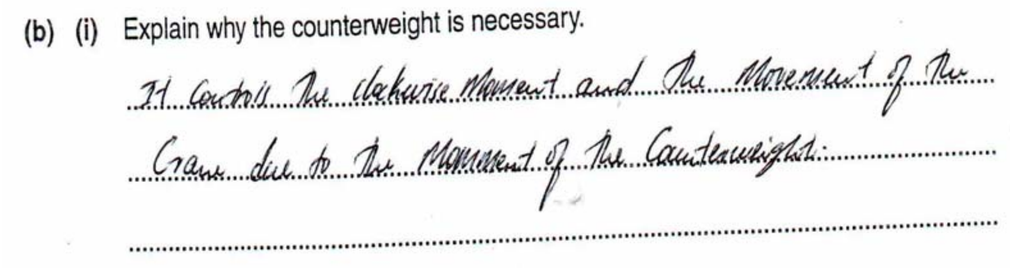

(b) (i) Explain why the counterweight is necessary.

It is necessary because it helps to balance the moment i.e. the moment about the counter weight is greater that that of bricks then the bricks will be lifted up and when is reduced they will come down

... of being able to move the counterweight along the arm.

Figure 2. Thabiso's response.

In this extract, Thabiso is justifying his claim that "… it helps to balance the moment…". The second category is of students who did not justify their reasoning. Thabang gave the following response (see Figure 3).


(b) (i) Explain why the counterweight is necessary.

It controls the clockwise moment and the movement of the crane due to the moment of the counterweight.

Figure 3. Thabang's response.

Although none of the students made reference to the principle of moments, their responses reflect an understanding of the principle. It can, therefore, be argued that the teaching did not compromise the learning of the concept and that students could pass the external examinations. It is also critical to note, however, that the general structure of external examinations, in terms of marks allocation, does not necessarily promote argumentation.

Discussions and Conclusions

The results of this study reflect important lessons about the teaching of science at secondary level in Lesotho where need for learner-centered approaches cannot be over emphasized. The study highlights two important findings. Specifically, it shows the argumentation as a feasible strategy of teaching and underlines challenges associated with introduction of this new approach. The results show that students participated in activities that encouraged argumentation. This result complements findings made elsewhere. For instance, von Aufschnairer, Erduran, Osborne, and Simon (2008) have shown that their samples from 12- to 13- year-old benefited from introduction of argumentation. Firstly, argumentation helped their students to draw on their past experience and knowledge. Secondly, students were able to consolidate their prior knowledge and employ it at a higher level of argumentation. Argumentation can, therefore, be used as a teaching strategy in Lesotho.

There are lessons to be drawn about argumentation from this study. Firstly, students have demonstrated change in how they talk science. It is helpful to view this change in terms of the claim that Gee (2005) made. The gist of his argument is that students must be willing to accept change for any new strategy to succeed. The results also show that as students practiced argumentation, they were also learning physics. Secondly, performance of students highlights a reasonable expectation that if taught using argumentation students can still perform well in external examinations. Therefore, the study highlights the potential in argumentation to be used as a teaching strategy and possibly improve performance in external examinations.

However, it cannot be overemphasized that effective introduction of argumentation in science classrooms in Lesotho requires teachers to change their strategies. Qhobela and Moru (2009) observed that the situation in Lesotho should be seen as a problem of PCK (pedagogical content knowledge) than of many factors other researchers have stated. The greatest challenge therefore to introduction of argumentation in Lesotho is related to changing the tradition science teachers who have adopted. The results show that even though the status of equipment and other teaching facilities are unsatisfactory, students are ready to participate. According to Posner, Strike, Hewson, and Gertzog (1982), change starts from the feeling of “dissatisfaction”. Therefore, causing dissatisfaction among teachers remains an important process. The results of this study show that students often make short sentences. This means that if teachers can use argumentation in their teaching, they have to address this problem. The results also show that argumentation improved with use of mother tongue. This means that teachers need to allow use of code switching in a more planned way in their classes.

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