Students' experiences with mathematics teaching and learning: listening to unheard voices

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This study documents students' views about the nature of mathematics, the mathematics learning process and factors within the classroom that are perceived to impact upon the learning of mathematics. The participants were senior secondary school students. Qualitative and quantitative methods were used to understand the students' views about their experiences with mathematics learning and mathematics classroom environment. Interviews of students and mathematics lesson observations were analysed to understand how students view their mathematics classes. A questionnaire was used to solicit students' views with regards to teaching approaches in mathematics classes. The results suggest that students consider learning and understanding mathematics to mean being successful in getting the correct answers. Students reported that in the majority of cases, the teaching of mathematics was lecture-oriented. Mathematics language was considered a barrier in learning some topics in mathematics. The use of informal language was also evident during mathematics class lessons.

Keywords: mathematics teaching and learning; classroom experiences; qualitative approach

1. Introduction

Mathematics teaching and learning is a national concern in Botswana. A study contracted by the National Commission on Education [1] to analyse performance in science and mathematics concluded that mathematics was in a 'parlous state'. Taole and Chakalisa [2] reported similar results and also revealed that performance in public examinations in science and mathematics is often poor. Studies cited in the Report of the National Commission on Education [1] identified the poor quality of teaching at senior secondary school level, especially in science, mathematics and English as one of the factors responsible for the poor quality of Cambridge O-Level School Certificate completers. In addition, studies of Botswana classroom teaching reveal that the teaching of mathematics concentrates more on procedural content knowledge than on conceptual knowledge [2–4].

The prevailing view of the nature of mathematics in Botswana schools is that it is a static collection of definitions, rules and algorithms that are to be followed when solving mathematics problems [2]. According to this view, 'doing and understanding mathematics' refers to recalling memorized rules and procedures and apply them correctly to obtain correct answers. Consistent with this view are the conceptions that mathematics is

composed of distinct topics taught in isolation from each other and that 'real' mathematics is abstract, with no relation to real life situation [5]. Such views reinforce myths about what it means to know and learn mathematics, myths that are popular yet dysfunctional for students [6].

Teaching students set of procedures and rules that they consider as 'proper way' of solving problems poses some dangers [7]. Students who are required to memorize methods and procedures in mathematics will inevitably believe that mathematics is mainly a matter of following disconnected rules and symbols [8]. Furthermore, this reliance upon authority is communicated to students who are likely to have goals that are more social than mathematical [9]. Seeking to emulate a procedure or the algorithm demonstrated in mathematics class might have more to do with gaining approval than with making sense of mathematics. However, instructional practices that focus on learning and developing understanding rather than on performing better than others contribute substantially to students feeling of competence [10]. Borasi and Seigel (1994) cited in Seigel et al. [11] suggest that by allowing students to experience and appreciate first-hand ambiguity, non-linearity and conscious guessing associated with mathematical thinking, is one way to demystify mathematics learning for the students. In addition, Boaler [12] reports that students who are exposed to instructions that emphasize flexible thinking and application of mathematics to novel situations are reported to outperform those whose instructions emphasized procedures and memorization.

Lubienski [13], however, has expressed reservations about reform-oriented teaching that involves the use of real-world contexts. Lubienski's concerns are about the potential of such instructional approaches for increasing the gap between low- and high-socio-economic students and between boys and girls. In support of these expressed concerns, Ball [14] argues that the context of teaching mathematics to a linguistically and cultural diverse class could be 'unevenly familiar or interesting and diminished the sense of collective purpose' (p. 672). Botswana is a multilingual and socio-economically diverse society. The socio-economic status of students in urban centres is different from those who live in the rural and remote areas. There are also cultural beliefs and expectations with regards to education in general, and to gender issues related to mathematics in particular. Lubienski's concerns may be evident even in Botswana and other developing African countries. Studies in some developed countries, however, report that some reform approaches do promote equity and high achievement [15,16].

2. Students' views about mathematics classroom

There is a growing recognition of the value of listening to students' views about education both in general terms and, more specifically, in relation to the classroom environment [17]. In fact, Carpenter and Fennema (1992) cited in Davis [18], in their analysis of the sort of teaching behaviours that contributed to more effective mathematics instruction, suggest that '…listening to their students was the critical factor' (p. 143). Kershner and Pointon [19] also cite reports that show that children of different ages can be perceptive and imaginative about teaching and learning. Kershner and Pointon further report that children's understanding of their classroom and participating in decision-making has educational relevance within the curriculum. In addition, evidence shows that students have a good vantage point to make judgements about classrooms. This is because they have encountered many different learning environments and have spent enough time in classrooms to have gained accurate impressions about them [20].

Bauerfeld [21] argues that consideration of the classroom, with its diverse participants, expectations and rituals is essential to the study of the construction of school knowledge of mathematics. In support of this observation, Bishop [22] notes that the classroom context is related to the general socio-cultural context that brings about the culturally constructed value of knowledge. In particular, the context in which mathematics is learned conveys images about the subject itself [23].

Learning mathematics in a particular context also affects students' beliefs about mathematics [9]. In her study, Raymond [24] points out the importance of past experiences in school mathematics in shaping personal beliefs of students. Other perceptions also point to the influence of beliefs on how students conceptualize and do mathematics [6]. Students' perception of the nature of mathematics is that mathematics is a kind of knowledge that can always be assessed in terms of correctness or incorrectness [25]. These perceptions may pose difficulties for teachers who may hold constructivist views of mathematics and want to teach mathematics in a constructivist manner. The views that students hold of the nature of mathematical knowledge are an important component in the culture of the mathematics classroom since it is linked with the way mathematics is taught and received. The case of Fred [26] illustrates how the social context of the classroom contributes to how mathematical activities become defined. Students in Fred's class complained that he was 'making a joke out of mathematics and that they were failing because he never got down to the serious work of adding, subtracting, multiplying and dividing fractions and decimals' (p. 332–333).

There is a growing concern among mathematics educators that many students are able to learn mathematics for 11 years or more but are then completely unable to use this mathematics in situations outside the classroom context [12]. Some students view mathematics as an exclusive domain in the sense that mathematics is something that occurs only in school [27]. Evidence that students hold views that in-school mathematical activities are separate from out-of-school mathematical activities has also been reported by other researchers [28].

Cobb et al. [29] describe the school and classroom site as a community in which children are expected to publicly express their thinking, and engage in mathematical practice characterized by conjectures, arguments and justifications. Schools and classrooms are, however, complex social environments consisting of different groups of individuals interacting with each other in different ways. The individuals have their perceptions about learning environments and the values of education. Teaching and learning will be affected by these factors. The students' views of mathematics throughout their academic life also points to the importance of the influences they are exposed to during their school life. Students in their early school years become acquainted with the mathematics content through numerous activities and problems assigned by their teachers. Such activities and problems as these, influence their motivation and interest in mathematics.

Lindenskov [30] notes that students' perceptions of what mathematics is, influences their interpretation of what is taught. One belief is that to do mathematics well, and therefore by implication to learn it well, one requires the possession of fast thinking capabilities. Such a view, can lead a student towards developing unproductive cognitive and affective orientations [31]. In support of this observation Schoenfeld [32] explains that:

> ...students' problem solving performance is not simply a product of what the students know; it is a function of their perceptions of the knowledge, derived from their experiences with mathematics. Their beliefs about mathematics...establish the psychological context within which they do mathematics. (p. 14)

In recent years, however, mathematics educators have focussed attention on rethinking the process of mathematics education at all levels [33]. However, much of the recent efforts to improve mathematics instruction in Botswana have focussed on professional development activities designed to promote instruction that is consistent with the recommendations of the Botswana Reports of the National Commissions of Education [1,34]. These reports are now over 10 years old, and so the study wishes to hear current students' views so as to see if they confirm the reports' findings 10 or more years later.

2.1. *Structure of the school system in Botswana*

The Botswana primary school[1] system is a 7-year (Grade 1–7) programme. The primary school system features a primary school leaving examination (PSLE) for entry to community junior secondary schools (CJSS). The PSLE, however, is not used for selective purposes, but is a criterion referenced examination. The CJSS is a 3-year programme that is characterized by a selective junior certificate (JC) examination, which is used for entry to senior secondary schools.[2] At the CJSS level, students follow a common curriculum of five core subjects, including mathematics. Students also take different optional courses. At the senior secondary school level, the picture is a little complicated. The senior secondary school level is a 2-year programme. It leads to a selective Botswana general certificate for secondary education (BGCSE) examination that is used for entry to the University of Botswana and other institutions of higher learning. Students at senior secondary school level choose courses from three main areas and optional courses from other remaining areas. Mathematics, English, Science and Setswana (local language) are mandatory courses. Mathematics is divided into core, extended and additional mathematics. All students take the mathematics core courses. The extended and additional mathematics courses are taken only by the best students. Only students who obtained 70% and above in the CJSS mathematics examinations are eligible to take either the extended or additional mathematics courses. These students also take all science subjects (Biology, Chemistry and Physics).

3. Purpose of the study

The study seeks to understand how senior secondary school students view the teaching and learning of mathematics in Botswana senior secondary schools. Developing an understanding of how students' view mathematics is an important step in helping students experience quality mathematics education. Students' views about mathematics classroom experiences have, however, never been solicited to assist in providing insights on how to improve mathematics instructions in schools. Students' views about mathematics and mathematics teaching and learning can be taken into consideration when designing a mathematics curriculum that addresses their concerns about mathematics learning. Understanding the students' concerns could also influence the use of a variety of instructional practices in mathematics classes.

4. Method

This case study is part of a larger study that investigated teachers' and students' views about mathematics and mathematics teaching and learning. In this study, I mainly used qualitative case study approaches because I wanted to understand the relationship between the students' day-to-day experiences in their respective mathematics classrooms and their

views about mathematics teaching and learning. I wanted to hear students' actual voices about the teaching and learning of mathematics. For me, this was very significant because it brought to the forefront the concerns of the recipients of mathematics instructions. It also provides a forum from which we can critique and assess our teaching with the view to improving on it.

The research methods enabled me to develop a comprehensive understanding of the students' experiences with mathematics and mathematics learning and it helped me to begin to view the mathematics classroom environments from the students' viewpoints. Boaler [35] sees the qualitative approach as offering a lens through which to examine and describe what she calls 'colors and contours of mathematics classrooms', and giving names to some of the important choices to which students attend in the process of mathematics teaching and learning.

4.1. *Participants*

Participants in this case study are senior secondary school students from three secondary schools in Gantsi, Central and Ngamiland Districts. The schools are chosen because they are in rural areas where traditions are still likely to be observed and emphasized. The main reason for selecting them was to listen to the voices of final-year students whose parents are mainly, either farmers, or not in formal employment, as is often the case in far-flung locations thousand of kilometres from the capital, Gaborone. That these students are in their final year is significant to the study since performance in this year determines admission into tertiary institutions. A total of 200 students participated in the study. About 60% (120) of the students were females.

4.2. *Data collection*

A questionnaire was administered to all students in the study. The questionnaire focussed on specific items pertaining to the students' experiences with mathematics teaching and learning (Appendix A). I also interviewed 10 students from each of the three secondary schools, analysed comments elicited from students about mathematics classroom events. The interviews involved both students who were and those who were not successful in mathematics in their respective schools. Out of the 10 interviewed students, 7 had volunteered for the interviews. All the students who volunteered were reported by their teachers to be successful in mathematics. With the mathematics teachers' assistance the other three students were selected. They were chosen because the teachers regarded them as below average students particularly in mathematics. The interview items focussed on items on the questionnaire. The purpose for this approach was to provide a balance perspective of students' expressed views and their responses to the questionnaire. To understand students' experiences in the process of learning mathematics, I also observed 30 different mathematics lessons, taking the role of a participant observer [36].

4.3. *Data analysis*

Qualitative data were analysed using three broad areas relating to mathematics instruction (nature of mathematics, views on learning mathematics and factors within the classroom that students perceive to affect the learning of mathematics). The analysis of these components of mathematics was done by open coding [37]. For the analysis of data on

learning mathematics, the keywords include references to procedures, concepts, structure, processes and assessment. The questionnaire focussed on types of teaching styles commonly used in the mathematics classes. The responses to the students' questionnaire were analysed in two ways. The first analysis used frequency count of students' choices to each teaching style used in mathematics classes. These were, in turn, used to describe how students perceive their mathematics classroom lessons.

5. Results

5.1. *The nature of mathematics*

Two items were used to assess students' beliefs about the nature of mathematics. The first item referred to students' beliefs about mathematics as a subject. Students in most of the schools visited described mathematics as a series of equations, and formulae. This was in contrast to how Collis and Romberg (1991) as cited in Boaler [38] described mathematics. Collis and Romberg described mathematics as a subject that encourages critical thinking, reasoning, solving problems and interpreting and applying ideas. Cultural and socio-economic status may account for these differences. Students in this study are from rural traditional farming communities. They consider mathematics as one of the subjects in the school curriculum. This view might influence how they value the importance of mathematics as a discipline.

The students in this study believed that there were a lot of methods to remember for them to be successful. The remembering of methods is an indication to them that they understand mathematics. This limited view of mathematics stems from the fact that success is measured in terms of how many correct answers one gets in a test. During the interviews, one student remarked; 'You can't pass maths tests without getting correct answers'. I asked him about the possibility of doing the procedures correctly but arriving at an incorrect conclusion. He said, 'Then you do not know enough mathematics. You should get the answers correct. How can you get an incorrect answer from an accurate procedure? That is a requirement. You will loose points by getting the answer wrong'.

The second item refers to students' beliefs about someone being good or bad at mathematics. When interviewees responded to an item about defining someone as good or bad at mathematics, they revealed much of their thinking about the aspects of the subject that they think are important. Such descriptions also indicate the dominant views regarding the nature of mathematics. Some interviewees perceived mathematics as a set of rules and formulas that must be memorized and applied when the need arose. Students who are regarded as good at mathematics (literally known by students as 'Di Solvy'), are those who have been successful in memorizing the rules and formulas. Other interviewees, on the other hand, conceive mathematics as a set of procedures and concepts that are not arbitrary pieces that must be memorized, but can be understood. Understanding about these procedures and concepts can come about through class discourse and application.

5.2. *Respondents' views on learning mathematics*

From the data analysis, two issues emerged as affecting students' learning of mathematics. The first issue concerned students' beliefs about the way they learn mathematics. In their comments, the interviewees mention numerous contributing factors to mathematics learning. The comments ranged from inherited capabilities to hard work and assistance being given by teachers. From the conversations with students, four sources of

mathematics accomplishments (or lack of accomplishment) were identified as: innate ability, time spent working on mathematics exercises, perseverance or confidence in one's ability to succeed with material (or avoidance of work or lack of confidence), and good or bad teaching. Understanding mathematics is tied only to successful performance on tests and examinations. Knowing 'how' supersedes what appears to be less important, that is knowing 'why'. The view that mathematics should be straightforward and that exploratory methods are a 'waste of time' was common among the students. Such views about mathematics and mathematics learning were also reported in other studies [39,40].

The second issue relates to students' beliefs about the effort needed in order to succeed in mathematics. The respondents were more interested in high grades than understanding the mathematical concepts and meaning involved. They wanted precise instruction and closely prescribed tasks. They wanted assurance that studying hard leads to good test and examination scores. Xholiso (pseudonym of the respondent) said, 'If I can remember the procedures of solving problems, I know I will pass mathematics exams. Although our teacher encourages us to understand the problems, we always resort to memorizing formulae. In our study group we try to recall how certain problems could be solved'. It is, however, understandable that students in senior secondary schools in Botswana should be concerned with high grades. Entry to the University of Botswana and other institutions of higher learning including Polytechnics is competitive. Most of the programmes in these institutions require high grades in mathematics, science and English.

5.3. *Factors affecting classroom learning*

There were two issues that students considered to play a significant role in the learning of mathematics. One major issue that students thought affects their performance in mathematics learning concerns the use of English as a medium of instruction in teaching and learning mathematics. The particularity of the language used in mathematics contexts suggests there are significant differences between mathematical English (ME) and ordinary English (OE). The ME language involves English language that is distinctly different from other types of communication. It often entails a considerable exposure to symbols and symbolic manipulations. More specifically, students in this study believed that word-problems were the most difficult types they encounter in mathematics tests. Some students reported frustration when translating word-problems into equations or algebraic expressions. They also acknowledge that language tends to be a barrier in determining the meaning of the problem. This observation is in support of Secada's [41] observation that 'language proficiency, no matter how it is measured...is related to mathematics achievement' (p. 639). One student remarked that, 'The English language in mathematics context seem to be always different from the English we learn in English classes. The mathematics English is technical and difficult to translate into the local language (Setswana)'.

Students in the mathematics classes I observed tended to use what Setati [42] calls formal and informal language. Students' spoken and written modes of formal and informal mathematics were carried out in what Sfard et al. [43] call mathematics discourses. Sfard and co-workers distinguish procedural from conceptual discourse in the mathematics classroom. Procedural discourse focusses on the discussions in which the main topic of conversation is the steps to be taken to solve a problem, and conceptual discourse as discussions in which the reasons for calculation in a particular manner becomes an explicit topic of conversation. In some of the classrooms I observed,

procedural discourse received much more emphasis than conceptual discourse. Involving students more in the procedural discourse, may be limiting students' acquisition of the mathematical literacy that is crucial in the understanding of mathematics. There were a few classes, however, where conceptual discourse was encouraged. In those classes students were encouraged to contribute their ideas and explain their methods to the whole class.

Finally, the other issue that relates to students' beliefs about mathematics learning and performance was gender related. Cultural expectations of students' performance in mathematics have been well defined. Such expectations influence students' effort in learning mathematics. In this study, boys boasted of being mathematically better than girls even though in the larger study some class teachers reported girls outperforming boys. Mura [44] reported similar observations. Girls, however, believed that boys are expected in society to do better in mathematics and science related course such as physics and chemistry. Mpho (fictitious name of one respondent) said, 'My brother has to do well in maths. My dad always tells him that. With me, he worries about my English. I want to do well in maths. I want to study computer science. I do not want to be a clerk or secretary'. Although girls were reported by their teachers to outperform boys, they believed their success was due to hard work. Jane (pseudonym of one respondent) said, 'I am not that good in maths. I try as hard as possible to pass maths tests. My friends, too, study hard. Boys always take things so lightly. They are so confident of themselves'. These observations were also reported in other studies in Botswana, and East and West African countries such as Kenya, Nigeria and Zambia [45]. Girls in this study, however, did not believe that mathematics was a male domain. During some of the interviews, some girls argued that boys are supposed to study more mathematics because they are the ones that like to do physics-related courses. Some interviewees (boys and girls) did not agree with this stereotypical view. They talked of the view as undermining women's independence.

5.4. *Findings from questionnaire*

The students' questionnaire had items dealing with classroom practices. Students were asked to think of their mathematics classes during a typical school week and indicate whether each teaching approach took place 'almost everyday', 'often', 'rarely' or 'never'. Of all the responses received, about 90% of the students indicated that mathematics classroom teaching was more lecture-oriented, involving review of assignments followed by individual seat work with the teacher walking around the class. Teacher explaining alone was reported to occur most frequently (70%), while individual help received the least (40%) responses. These findings concur with Mapolelo's [4] study on primary school teachers' mathematics teaching styles. Mapolelo found that teachers used teacher-centred approach more than any other teaching styles. Although teachers in classes I observed this in study moved around in their respective classes during students practice sessions, it was more on checking whether or not students were following the taught procedures rather than providing assistance to those who may not have understood the concept taught.

Comparison of teachers' responses in the larger study mentioned earlier, with students' responses in this study suggested that teachers tended to rate most of the classroom practices as 'occurring most frequently'. The students on the other hand, mostly rated the items as 'sometimes occurring'. A common finding across the curriculum is that teachers tend to report their work as taking place in 'interactive' student-centred classrooms. Observations (and students' comments) confirm the opposite, lecturing remains dominant.

This difference between how teachers and students view classroom practices illustrates one of the difficulties of mathematics teaching in our schools.

One other factor that students pointed out as a serious concern was the assessment of their mathematical competency. During the interviews students complained that assignments did not count towards their final examination mathematics grades. The mathematics examination assessments procedures do not include projects or experiments as in science. One student said, 'We waste a lot of time doing assignments. Assignments are only for practice, rather than contributing to our final grade. I think it is worthwhile we include our assignment grades as part of the final grade'.

5.5. *Mathematics classrooms: findings from lesson observations*

A typical mathematics class begins with a review of the previous lesson. This is followed by a demonstration on the board by the teacher. The timetables of classes I observed showed that a mathematics class was a 50-min period. All mathematics classes were timetabled for morning sessions. The class sizes averaged 35 students. The topics taught in the classes I observed were different. Topics covered in these classes included solving quadratic equations, trigonometry, graphs, volumes and areas, and ratio and proportions.

In most of the mathematics classroom lessons I observed, the students demonstrated a large degree of non-involvement. Passivity was demonstrated by students quietly copying down procedures without showing any desire to question their applicability to real-life situations. Teachers' frequent cautioning of students who were seen whispering reinforced this observed phenomenon. This observation concurs with reports in Snyder and Fuller [3] study. Snyder and Fuller report that the teaching of mathematics in Botswana schools was boring and uninspiring. It seemed that the classroom environment as a social context has a number features of that were suppressing the students' willingness to think mathematically. This thinking was not in accord with the way required and described in the Reports of the National Commission on Education [1,34].

Findings from interviews I had with the students were in both Setswana (the national language) and English. The use of local language was to allow all students to express themselves as freely as possible. The following conversation was conducted in Setswana and then later translated into English. The conversation was with one respondent identified by his teacher as very good in mathematics.

Researcher: How would you describe the way you learn mathematics?
Interviewees: Mathematics requires a lot of effort and practice. We try to spend as much time as possible trying to understand maths. We try to work as a group.
Researcher: What do you mean by 'understanding maths?'
Interviewees: Well, I mean trying to remember some important concepts such as $\cos^2 + \sin^2 = 1$ or the properties of indices.
Researcher: What do you think is the role of the teacher in your learning mathematics successful?
Interviewees: Teachers are supposed to assist us in every possible way, but the student must put a lot of effort.
Researcher: Do teachers do this? Assisting you?
Interviewees: Some teachers do, but others don't. They either refuse or only give you more confusion.

Students' comments in interviews and their behaviours in mathematics lessons suggest that they are over-reliant upon teacher's authority and seeking to gain approval rather than making sense of mathematics. Students want a teacher to be in-charge of the mathematics

knowledge they learn in class. Students, however, raised concerns about the pronunciation of some mathematical terms. In one interview, Millo (pseudonym of the respondent) commented: 'We listen and copy everything our teachers teach us. If we have good maths teachers, we can do well in our final exams. Some teachers are difficult to understand, particularly non-locals. We struggle to get what they try to say. We had a teacher who pronounced zero as if he was saying Zaire'. Cobb [9] reported similar observations when he wrote, '... students reorganize their beliefs about mathematics to resolve problems that are primarily social rather than mathematical in origin' (p. 2).

6. Conclusion

Data from this study revealed some interesting issues regarding students' views about the nature of mathematics, factors affecting the learning of mathematics, and mathematics classroom experiences. Listening to students' views about the nature of mathematics and factors that affect mathematics learning was refreshing and informative. The views expressed by the students about mathematics were important because students are the recipients of the mathematics instructions. Students' description of mathematics as a subject that emphasizes correct answers and requiring memorization of procedures is a crucial factor in the learning of mathematics. These students' views corroborate with the views expressed in other studies [2]. These views about mathematics and mathematics learning can have a substantial impact on their interest in mathematics, their enjoyment of mathematics, their motivation in mathematics classes. Students' experiences of a mathematics class indicate a possible source why the majority of people dislike mathematics.

The other major factor affecting the mathematics teaching and learning in Botswana schools is the impact of English as a medium of instruction. In this study, like in others studies in Botswana [46,47], the impact of English language in mathematics teaching and learning was viewed as a barrier particularly in understanding and solving word-problems. Students in this study report that word-problems are exceptionally difficult especially if the problems require translation of verbal information into mathematical equations.

The greater part of the literature cited in this study supports the view that reforming mathematics instruction in schools is necessary. Studies of Botswana classroom teaching in particular [2,3,48,49] and Reports of the National Commissions on Education [1,34] advocate the need for child-centred pedagogy that is oriented to social constructivist epistemology. Yet in this study, students reported that the lecture-method was more commonly used in most of the mathematics classes. There is a need to investigate why teachers tend to use lecture-method more often than other teaching styles. There is also need for research on whether or not the advocated teaching approaches are superior to the lecture-method that is being discouraged in mathematics classes. Do students who are taught mathematics through these advocated methods become more mathematical literate than their counterparts? Finally, research is necessary on the issues relating to the impact of the use of English as a medium of instruction in mathematics teaching specifically on students achievement. There is little research in Botswana that focusses on the relationship between English proficiency and mathematics achievement.

Notes

1. Primary school refers to the first 7 years of basic education (age range: 7–14 years).
2. Senior secondary school refers to the last 2 years of secondary education (age range: 15–20).

References

[1] Government of Botswana, *Report of the National Commission on Education*, Gaborone, Government Printers, 1993.

[2] J.K. Taole and P.A. Chakalisa, *Implications of the national commission on education for mathematics education*, Mosenodi 2 (1995), pp. 15–22.

[3] C. Snyder and B. Fuller, *Vocal teachers, silent pupils? Life in Botswana classrooms*, Comp. Educ. Rev. 2 (1991), pp. 274–294.

[4] D.C. Mapolelo, *Primary school mathematics teaching: What do teachers focus on in Botswana?* Mosenodi 9 (2001), pp. 3–15.

[5] M. Armit and S. Hillman, *Changing mathematics instruction and assessment; challenging teachers' conceptions*, in *Mathematics Teacher Education*, B. Jawoski, S. Dawson, and T. Woods, eds., Graphicraft Limited, Hong Kong, 1999, pp. 17–25.

[6] A. Schoenfeld, *Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics*, in *Handbook of Research on Mathematics Teaching and Learning*, D.A. Grouws., ed., MacMillan, New York, 1992, pp. 334–370.

[7] French, D. (1992, September 10). 'Time to use your loaf'. *Times Educational Supplement*, p. XV.

[8] J. Hiebert and T.P. Carpenter, *Learning and teaching with understanding*, in *Handbook of Research on Mathematics Teaching and Learning*, D.A. Grouws, ed., MacMillan, New York, 1992, pp. 65–97.

[9] P. Cobb, *Contexts, goals, beliefs, and learning mathematics*, Learn. Math. 2 (1986), pp. 2–9.

[10] D. Stipek, J.M. Salmon, K.B. Givvin, E. Kazemi, G. Saxe, and V.L. MacGyvers, *The value (and convergence) of practices suggested by motivation research and promoted by mathematics education reformers*, J. Res. Math. Educ. 4 (1998), pp. 465–488.

[11] M. Siegel, R. Borasi, and J. Fonzi, *Supporting students' mathematical inquiries through reading*, J. Res. Math. Educ. 4 (1998), pp. 378–413.

[12] J. Boaler, *Open and closed mathematics: Students experiences and understandings*, J. Res. Math. Educ. 1 (1998), pp. 41–62.

[13] S. Lubienski, *Problem solving as a means towards mathematics for all: An exploratory look through the class lens*, J. Res. Math. Educ. 31 (2000), pp. 454–482.

[14] D.L. Ball, *Transforming pedagogy: Classrooms as mathematical communities – A response to Timothy Lensmire and John Pryor*, Harvard Educ. Res. 65 (1995), pp. 670–677.

[15] J. Boaler, *Experiencing School Mathematics: Teaching Styles, Sex, and Setting*, Open University Press, Buckingham, 1997.

[16] E.A. Silver, M.S. Smith, and B.S. Nelson, *The QUASAR project: Equity concerns meet mathematics reforms in the middle school*, in *New Directions in Equity in Mathematics Education*, W.G. Secada, E. Fennema, and L.B. Adajian, eds., Cambridge University Press, New York, 1995, pp. 9–56.

[17] J. Rudduck, R. Chaplain, and G. Wallace, *School improvement: What can pupils tell us?* Fulton, London, 1996.

[18] B. Davis, *Listening for differences: An evolving conception of mathematics teaching*, J. Res. Math. 3 (1997), pp. 355–376.

[19] R. Kersher and P. Pointon, *Children's views of the primary classroom as an environment for working and learning*, Interdiscipl. Int. Res. J. 64 (2001), pp. 64–77.

[20] B.J. Fraser, *Research on classroom and school climate*, in *Handbook on Research on Science Teaching and Learning*, D.C. Garbel, ed., MacMillan, New York, 1994, pp. 495–541.

[21] H. Bauerfeld, *Classroom cultures from a social constructivist's perspective*, Educ. Stud. Math. 23 (1992), pp. 467–481.

[22] A.J. Bishop, *Mathematics Enculturation: A Cultural Perspective on Mathematics Education*, Kluwer Academic Press, Dordrecht, The Netherlands, 1988.

[23] C. Desforges and A. Cockburn, *Understanding the Mathematics Teacher: A Study of Practice in First School*, Falmer, London, 1987.

[24] A.M. Raymond, *Inconsistency between a beginning elementary school teacher's mathematics beliefs and teaching practice*, J. Res. Math. Educ. 5 (1997), pp. 550–576.
[25] M. Nickson, *The culture of the mathematics classroom: An unknown quantity?* in *Handbook of Research on Mathematics Teaching and Learning*, D.A. Grouws, ed., MacMillan, New York, 1992, pp. 101–114.
[26] T.J. Cooney, *A beginning teacher's view of problem solving*, J. Res. Math. Educ. 16 (1985), pp. 324–336.
[27] V.L. Kouba and J.L. McDonald, *What is mathematics to children?* J. Math. Behav. 10 (1991), pp. 105–113.
[28] T.N. Carraher, D.W. Carraher, and A.D. Schlieman, *Mathematics in the streets and in schools*, British J. Dev. Psychol. 3 (1985), pp. 21 29.
[29] P. Cobb, T. Wood, and E. Yackel, *Discourse, mathematical thinking, and classroom practice*, in *Contexts for Learning: Sociocultural Dynamics in Children's Development*, E. Forman, N. Minick, and C. Stone, eds., Oxford University Press, New York, 1993, pp. 77–119.
[30] L. Lindenskov, Exploring the students own mathematics curriculum, *Constructivist interpretations of teaching and learning mathematics*. in *Proceedings of the seventh International congress on mathematics education*, J.A. Malone and P.C.S. Taylor, eds., Quebec, Canada, 1993, pp. 149 156.
[31] D.K.J. Mtetwa, *On the nature of mathematical knowledge: Teaching students both mathematics and about mathematics*, S. Afr. J. Math. Sci. Educ. 3 (2000), pp. 53–62.
[32] A. Schoenfeld, *Mathematical Problem Solving*, Academic Press, San Diego, 1985.
[33] C. Christou and G.N. Philippou, *The structure of students' beliefs towards the teaching of mathematics: Proposing and testing structure model*, in *Proceedings of the Twenty-second Conference of the Psychology of Mathematics Education*, Vol. 2, A. Olivier and K. Newstead, eds., Stellenbosch, South Africa, 1998, pp. 192–199.
[34] Government of Botswana (1994). The Revised National Policy on Education. Government Paper No. 2 of 1994. Gaborone: Government Printers.
[35] J. Boaler, *Learning from teaching: Exploring the relationship between reform curriculum and equity*, J. Res. Math. Educ. 4 (2002), pp. 239–258.
[36] M.A. Eisenhart, *The ethnographic research tradition and mathematics education*, J. Res. Math. Educ. 19 (1988), pp. 99–114.
[37] A. Strauss and J. Corbin, *Basics of qualitative research-grounded theory: Procedures and techniques*, Sage & Newbury Park, CA, 1990.
[38] J. Boaler, *Learning to lose in the mathematics classroom: A critique of traditional schooling practices in the UK*, Qual. Stud. Educ. 1 (1995), pp. 17–33.
[39] R.G. Roulet, *Exemplary mathematics teachers: Subject conceptions and instructional practices*. Doctoral dissertation, Ontario Institute for studies in education of the University of Toronto, 1998.
[40] S.I. Brown, T.J. Cooney, and D. Jones, *Mathematics teacher education*, in *Handbook of Research on Teacher Education*, W.R. Houston, M. Haberman, and J. Sikula, eds., MacMillan, New York, 1990, pp. 639–656.
[41] W.G. Secada, *Race, ethnicity, social class, language, and achievement in mathematics*, in *Handbook of research on mathematics teaching and learning*, D.A. Grouws, ed., MacMillan, New York, 1992, pp. 623–660.
[42] M. Setati, *Code-switching in a senior primary class of second language mathematics learners*, Learn. Math. 18 (1998), pp. 34–40.
[43] A. Sfard, P. Nesher, L. Streetland, P. Cobb, and J. Mason, *Learning mathematics through conversation: Is it good as they say?*, Learn. Math. 18 (1998), pp. 41–51.
[44] R. Mura, *Sex related differences in expectations of success in undergraduate mathematics*, J. Res. Math. Educ. 18 (1992), pp. 15 24.
[45] L.M. Kaino, *Some Swaziland high school students' attitudes towards the study of mathematics*, J. S. Afr. Assoc. Res. Math. Sci. Educ. 1 (1998), pp. 33–40.

[46] B. Menyatso, *An assessment of Botswana Junior Secondary School students' difficulties in solving word-problems*. Unpublished M.Ed Special Research Report. University of Botswana, Gaborone, 1996.
[47] D. Kasule and D. Mapolelo, *Teachers' strategies of teaching primary school mathematics in a second language: A case of Botswana*, Int. J. Educ. Dev. 25 (2005), pp. 602–617.
[48] R.B. Prophet, *Views from Botswana junior secondary classrooms: Case study of a curriculum intervention*, Int. J. Educ. Dev. 15 (1995), pp. 127–140.
[49] R.B. Prophet and P.M. Rowell, *The curriculum observed*, in *Curriculum, in the classroom: Context of change in Botswana's junior secondary schools instructional program*, C.W. Snyder and P.T. Ramatsui, eds., MacMillan, Gaborone, 1990, pp. 1–42.

Appendix A

Students Questionnaire on the teaching and learning of mathematics

For the statements below, please kindly indicate your agreement or disagreement by circling the number that expresses what you think about the statement. Your replies to these statements can range from **strongly agree (SA or 1)** to **strongly disagree (SD or 7)**.

(I) Your views about mathematics

(1) Mathematics just isn't my strength and I avoid it whenever possible. **1 2 3 4 5 6 7**
(2) I am good at mathematics and I enjoy the challenge of it. **1 2 3 4 5 6 7**
(3) I can handle basic mathematics, but I don't have the kind of mind needed to do advance mathematics. **1 2 3 4 5 6 7**
(4) I feel okay about mathematics. While I 'm not especially strong at it, I 'm not fearful of it either. **1 2 3 4 5 6 7**
(5) If I would give it full effort, I know I could learn advance mathematics. **1 2 3 4 5 6 7**
(6) Doing mathematics allows room for original thinking and creativity. **1 2 3 4 5 6 7**
(7) Doing mathematics is usually a matter of working logically in a step-by-step fashion. **1 2 3 4 5 6 7**
(8) A lot of things in mathematics must simply be accepted as true and remembered; there aren't explanations for them. **1 2 3 4 5 6 7**
(9) Junior and senior secondary algebra is totally unlike anything presented to students in primary schools. **1 2 3 4 5 6 7**

(II) The importance of Mathematics

(10) Mathematics helps me learn to think better. **1 2 3 4 5 6 7**
(11) Mathematics is needed for many jobs and careers. **1 2 3 4 5 6 7**
(12) To succeed in school, you need to be good in mathematics. **1 2 3 4 5 6 7**
(13) To be a well educated person, it is just as important to study major areas of mathematics as it is to read classic literary work. **1 2 3 4 5 6 7**

(III) Being good at mathematics

To be good at mathematics, you need to ...

(14) Remember formulas, principles, and procedures. **1 2 3 4 5 6 7**
(15) Think in a logical step-by-step manner. **1 2 3 4 5 6 7**
(16) Have basic understandings of concepts and strategies. **1 2 3 4 5 6 7**
(17) Be able to think flexibly. **1 2 3 4 5 6 7**
(18) Have confidence you can do it. **1 2 3 4 5 6 7**
(19) Have a kind of "mathematical mind." **1 2 3 4 5 6 7**
(20) Work hard at it. **1 2 3 4 5 6 7**
(21) Be interested in mathematics. **1 2 3 4 5 6 7**

(IV) Classroom teaching

Under this sub-heading, think of your typical mathematics class and respond to each of these items. Indicate your responses by circling the number representing your observation. Almost everyday [1], Often [2], Rarely [3], Never [4]

(22) How are these teaching style used in your mathematics classes?

(a) Lecture-method (teacher talking). **1 2 3 4**
(b) Student-centered approach. **1 2 3 4**
(c) Group-work. **1 2 3 4**
(d) Investigating. **1 2 3 4**

Thank you very much for your precious time.