International Journal of Scientific Research in Education, JUNE 2012, Vol. 5(2), 117-129.

International Journal of Scientific Research in Education (IJSRE)

ISSN: 1117-3259

The Role of Senior Secondary School Mathematics Teachers in the Development of Mathematics Curriculum in Botswana

Modise Mosothwane[i]
Department of Primary Education
University of Botswana
Gaborone, Botswana
mosothwm@mopipi.ub.bw

Abstract

This study examines the role played by secondary school mathematics teachers in the development of mathematics curriculum. It was conducted using a sample of sixty senior secondary school mathematics teachers. The findings of the study suggest that the majority of senior secondary school teachers' play only a minor role in the development of the mathematics curriculum, but are active in the implementation and production stages. Subjects of the study reported that full participation in the development of the curriculum would help them to better implement the material because they would feel they 'own' it. Teachers use a variety of teaching methods and materials to promote effective learning. A stronger mathematics curriculum for senior secondary schools would emerge if teachers were encouraged to participate in the development process. A lack of teacher participation in the development of senior secondary school mathematics curriculum has implications for mathematics teaching, particularly now as Botswana build's its first university of science and technology. One such implication is the possibility of weaker students finding their way into the university and thus lowering the overall quality of mathematics performance. The paper concludes with suggestions and recommendations in the hope that these will help curriculum development officers to involve more senior secondary school teachers in the development of mathematics curriculum so as to strengthen mathematics education in Botswana.

Keywords: Senior secondary school, mathematics curriculum, centralized curriculum, BGCSE, SADC, Botswana.

Reference to this paper should be made as follows:

Mosothwane, M. (2012). The Role of Senior Secondary School Mathematics Teachers in the Development of Mathematics Curriculum in Botswana. *International Journal of Scientific Research in Education, 5*(2), 117-129. Retrieved [DATE] from http://www.ijsre.com.

INTRODUCTION

The role of mathematics teachers in the development of mathematics curriculum has not clearly been articulated by the Department of Curriculum Development and Evaluation of the Ministry of Education and Skills Development. Yet teachers, as professionals with appropriate educational qualifications, could play a very important role in this context. This study finds that teacher participation empowers teachers with knowledge, skills and expertise that render them confident and competent in curriculum implementation processes.

A Botswana-based study conducted by Wright (1995) found that the roles and responsibilities of teachers in the development of a curriculum have not been clarified and as such, there is likely confusion, duplication and conflict. The legitimate and necessary roles teachers should be playing in the development of curriculum must be clearly articulated if a quality curriculum is to be achieved. At the same time, Wright notes that teacher training and development has a pivotal role to play in terms of implementation, as the quality of the teacher often determines the likelihood of successful implementation.

Howson, Keitel and Kilpatrick (1981) assert that teacher participation in curriculum development is critical because teachers are the mediators between the curriculum and the child. They note, however, that the perception of the general public and of curriculum development officers is that a teacher's main role with regards to curriculum is limited to implementation.

A teachers' role in curriculum development varies from country to country because of national differences in expectations of teachers and conceptions of their responsibilities (Howson, et al, 1981). In many developed countries, such as Australia, the teacher is in fact viewed as a participant in the curriculum design and development process (Skilbeck, 2005). In developing countries, curriculum developments tend to be product-oriented, and the teacher's role is that of a consumer rather than producer.

In Botswana, curriculum development is 'top-down'. Curriculum development officers, with the help of outside experts, decide when it's time to initiate curriculum change and what that change will look like. This model is worrisome as it contributes to a lack of curriculum initiatives, input and ownership by teachers (Bayona, 1995). For Botswana it could mean a missed opportunity to develop a quality curriculum and hence a quality national education system. Howson, et al (1981) have noted:

> "Teachers may participate in the process of curriculum development, but they are usually treated more like guinea pigs than partners. Curriculum developers may recognize the need to get teachers committed to a new curriculum if it is to be successful, but the developers see the problem more as 'selling' the product rather than getting involvement in the process" (p.64).

This means the full potential of teachers in curriculum development in Botswana cannot be realized because they are by-passed by administrators and curriculum development officers. This top-down approach stands to impede the development of a quality curriculum as it is denies good quality teachers the opportunity to participate and negates the feedback they may be able to provide from their experience as implementers.

Teachers' involvement in curriculum development empowers them to use a variety of teaching methods and materials that could promote more effective learning. It is crucial for the successful implementation of any subject as teachers (much like other professionals) can be resistant to change, especially if that change originates outside the school. A case in point is that of the introduction of Modern Mathematics in Botswana in 1968 (Swartland, 2003). According to Swartland, when Modern Mathematics was introduced in secondary schools in Botswana, teachers were generally anxious, angry and frustrated, many children were confused, and many parents began to raise questions about the aims and importance of Modern Mathematics.

Teachers' participation in the development of curriculum enhances the success of the implementation of that curriculum because they feel they own it and as such are obliged to support it. In other words, teachers commit to the curriculum (Taylor, 2004; Bayona, 1995). In Britain in the 1960s, a number of mathematics projects failed because they were developed by curriculum developers to the exclusion of teachers who were to implement them (Howson, et al, 1981). In reference to today's context, Bayona (1995) contends:

> "The reality of the 'knowledge explosion' provides another argument in favor of teachers' involvement in curriculum processes. It is reasonable to conclude that, because of the burgeoning knowledge base, it is unlikely that a single curriculum developer, acting independently will be able to choose successfully the most appropriate curriculum packages on behalf of teachers and students in different geographic locations" (p.41).

Taylor (2004) is also of the view that teacher participation in curriculum development could strengthen their professional autonomy. In other words, teachers should feel that they are professionals and as such should enjoy the autonomy to teach mathematical concepts in ways that will promote effective learning. Corno (1977) observes that often no matter how they

are restricted in curriculum decision-making and by curriculum design, "behind doors teachers still do as their judgment dictates" (p.234). In Botswana, teachers' preferred approaches to teaching are not recognized and this limits their creativity and impinges upon their professional autonomy and growth.

For some scholars, teacher participation in curriculum development is favored because it brings in local experience from various areas or locations and this enriches the curriculum (Taylor, 2004). In this context, teachers should be given an opportunity to discuss how certain concepts or methods will affect students in their local areas. Taylor (2004) posits that "contextualized teaching and learning become more feasible since a participatory curriculum development approach will inevitably become context dependant, and will involve those who know their own situation best" (p.6). If local experience is taken into account during the development of a curriculum, the curriculum blue print is more likely to include concepts that cater for pupils from different locations and/or different ethnic groups (Taylor, 2004).

If local experience is taken into consideration during curriculum development, the National Curriculum will truly represent the values, cultures, and the norms of the nation. Taylor (2004) observes that "the likelihood of domination of processes and outcomes by a small, unrepresentative group is avoided" (p.6). Teacher participation in curriculum development ensures that the curriculum is relevant to students and the region (Hermsen, 2000).

Curriculum development officers in Botswana believe that few teachers should be given responsibility to develop the curriculum and that the entire task should be left to them (Mosothwane, 2008). Those who object to teacher involvement argue that curriculum is a specialist area and only people who have specialized in curriculum development should participate (Bayona, 1995; Eggleston, 1977). They contend that teachers have not received formal training as curriculum developers and hence should not participate in curriculum development. Bayona (1995) notes, "to become deeply involved in the development of the school curriculum, one needs not only teacher training qualifications in a specialist subject area or areas, but also knowledge, skills, and experience in the field of curriculum development" (p.44). Skilbeck (1984) opines, "since teachers are neither trained nor supported as curriculum developers and would, in fact experience the utmost difficulty if faced with the prospect of developing the curriculum as an on-going task, in-service training on a massive scale would be required' (p.32). Eggleston (1977) says such a move would be too expensive for governments. House (1977) observes:

> "The teacher has very limited access to new ideas and innovations. The teachers' professional information field is surprisingly restricted. Being lower in the organizational hierarchy, the teacher has fewer external contacts with other professionals. Even within the school itself, he seldom has face to face contacts with other professionals, or even with other adults, mainly because of time constraints,--. In addition, having information about new innovations is not the same as having access to them. Even if the teacher should hear about a successful innovation, he/she must wait until he/she has access to it, normally through the school districts" (p.24).

This observation may still hold in countries where curriculum is centralized. Some educators argue that teachers should be excluded from participating in curriculum development because primary teachers, for example, are weak in cognate areas and may not contribute effectively to hard core curriculum disciplines such as mathematics (Carl, 2009). This observation is somewhat faulty as primary teachers participate only in the development of curricula at the primary level of education.

Some researchers object to teacher involvement in curriculum development on the basis of lack of time (Carl, 2009; Bayona, 1995). They argue that teaching is a demanding and time consuming career, and that teachers will not have time to participate fully in curriculum development. Bayona (1995) argues "extensive demands placed on teachers beg the question of how they can get the time and resources to attend to creative thinking and deliberation with respect to curriculum development and problem solving" (p.45).

Nunam (1983) expressed concern that if teachers were to participate in curriculum development, arguments over what to include in and what to exclude from the curriculum would arise. Nunam noted that teachers always fail to reach a consensus on what to include or what to exclude from the curriculum, hence their exclusion from curriculum development.

Another argument raised by some for the exclusion of teachers from curriculum development pertains to resources (Bayona, 1995, Carl, 2009). From this perspective, the involvement of teachers would create a situation in which each and every teacher suggested the teaching materials she or he prefers. It would be far too costly for governments to meet the requests of all teachers.

THEORETICAL FRAMEWORK

This study is guided by a number of theoretical perspectives. The authors first suggested various roles teachers play in the development of the mathematics curriculum (Lloyd, 2004; Clarke, 1997; Howson, et al, 1981). These roles include researcher, leader, planner, developer, contributor, negotiator, judge, analyzer, student, manager, evaluator, diagnostician, examiner, implementer and material developers (Carl, 2009; Graven, 2002; Bayona, 1995; Marsh & Stafford, 1988; Harding, et al, 1976; Hunkins, 1972). These roles compose the framework for this study on teachers' participation in the development of senior secondary school mathematics curriculum.

Teachers are eager to get involved in curriculum development and the quest for more knowledge reinforces the role of teachers as researchers (Gray & Campbell-Evans, [n. d]). Teacher involvement in curriculum development activities can create new knowledge and expertise on strategies that could promote higher quality teaching. The role of teachers as leaders is also crucial in curriculum improvement. Teachers can be expected to provide leadership in selecting or producing teaching and learning materials and organizing workshops on how to implement a new curriculum (Howson, et al, 1981). Teachers are also planners. They can plan what should be included or excluded from the curriculum, and how to empower other teachers to teach the new curriculum. It is partly as planners that teachers become committed to the success of the new curriculum (Bayona, 1995).

Another major role of teachers is that of developers. As developers, teachers can be involved in all stages of curriculum development (Harding, Kelly & Nicodemus, 1976). In this way, teachers increase the success of the implementation process and so enhance professional autonomy.

Teachers have been found to play a crucial role as negotiators in curriculum development (Carl, 2009). They negotiate with curriculum development officers on who should be involved. They negotiate the timing of introducing the new curriculum. They also negotiate the launching of workshops to familiarize teachers with the new curriculum. In some cases, they decide who should teach the new mathematics curriculum. Furthermore, they negotiate for teaching materials that would facilitate the implementation process (Howson, et al, 1981). Sometimes they negotiate for the improved remuneration of teachers who will teach the new curriculum (Skilbeck, 2005).

Another important role that teachers can play is that of a judge. Teachers can judge if the implementation of a new curriculum has been successful by looking at the scores of pupils in final examinations. Furthermore, they can make a judgment on whether workshops conducted had an impact or effect on the implementation of the new curriculum. Teachers also play the role of learner (Graven, 2002). Teachers learn more about a new curriculum when they are involved. They are then able to link what they did in their pre-service training with what they actually do in curriculum development. This helps them to conceptualize curriculum development as a process. The role of teachers as evaluators is also very important. Teachers are able to identify problems or factors that could impede the success of a curriculum. Teachers can also evaluate how effective new systems of teaching and learning are. For example, they can evaluate whether or not a centralized curriculum system is working for students.

Teachers as managers of a curriculum can ensure that the curriculum succeeds. No manager would like to see his/her company collapse. Likewise, teachers like to see other teachers grow professionally. At the same time, there may still be those who are concerned because they have not been adequately trained or because they have limited time to contribute effectively (Bayona, 1995). The role of teachers as diagnosticians is highly prized in curriculum development. As diagnosticians, teachers are able to diagnose where the weaknesses of a curriculum are. For example if a curriculum lacks certain concepts essential to learning mathematics at higher levels of education, teachers would be able to identify and remedy such gaps. Teachers also play the role of analyzer. If teachers participate in the development of a curriculum, they can identify factors that will make the curriculum succeed or fail. Strategies can then be developed to facilitate the implementation process.

The main purpose of this study is to examine the roles played by mathematics teachers in the development of senior secondary school mathematics curriculum (mathematics taught in grades 10 and 11). The study was guided by the following research questions:

- What roles do teachers play in the development of mathematics curriculum?
- To what extent and under what conditions do mathematics teachers participate in the development of mathematics curriculum?
- What should be done to involve more teachers in the development of mathematics curriculum?

METHODOLOGY AND INSTRUMENTATION

Participants

Sixty senior secondary school mathematics teachers participated in this study which took place in May 2011. The participants were teaching mathematics in six senior secondary schools and were very familiar with the senior secondary school mathematics curriculum. Their teaching experience ranged from five to twenty-five years. Fifty eight of them had first degrees in education and mathematics and two had Masters degrees in mathematics. Teachers were selected on the basis of their willingness to participate in the study. They indicated in meetings held between them and the researcher that they were prepared to complete the questionnaires and to assess their roles in the development of the mathematics curriculum.

Data Collection

A questionnaire consisting of 12 items was designed for the study. The questionnaire was composed of open ended questions as well as objective items with options from which the participants were to choose the options they most agreed with. These objective items had between four and seven options to choose from. The purpose of providing many options was to give teachers an opportunity to examine the options and determine if any really represented their roles in the development of curriculum.

Validity and Reliability of the Questionnaire

To confirm the validity of the instrument, the questionnaire was given to two mathematics educators, one from the Ministry of Education and Skills Development and the other from the Department of Curriculum Development and Evaluation. The two educators were asked to match the objectives of the study with the six categories into which the study had been divided, namely, *ways of involving teachers*, *identification of teachers' roles*, *knowledge of curriculum development*, *posts of responsibility involved in curriculum development, stages of curriculum innovation*, and *conditions of involvement*. This matching of objectives with categories by two mathematics educators agreed 80% of the time with the researchers' study design. Simple descriptive statistics such as frequencies, tallies and percentages were used.

To establish the reliability of the instrument, a pilot study was conducted using mathematics teachers from one senior secondary school. The teachers involved in the pilot study suggested the inclusion of two additional items and consequently the items increased from ten to twelve. **Item 11** is Should Botswana senior secondary school mathematics include topics such as arithmetic, geometric progressions, binomial theorem and introduction to calculus in its mathematics curriculum so that it is on par with the South African Matriculation Mathematics Syllabus for Standard Grade. Answer options were Yes or No. If yes, why? If no, why not? **Item 12** is Provide any other information which you think will improve our current senior secondary school mathematics curriculum (please provide detailed information which could help us strengthen mathematics at the senior secondary school level of education). After conducting the pilot study, the questionnaire was administered to another sixteen teachers in two senior secondary schools. The researcher marked the scripts of the participants. The mean and the standard deviation of the raw scores were calculated and were inserted into the KR 21 formula. The reliability estimate of scores of the participants was calculated. The correlation estimate was calculated to be 0.68 and this was considered sufficient to allow the instrument to be used to collect data. However, it should be noted that KR 21 gives less accurate estimates.

Data Analysis

The data was analyzed using a method in which teacher responses were coded and then classified according to relevant themes. Some items of the instrument were analyzed using frequencies or the number of responses.

RESULTS

Item 1 sought information from respondents on ways of involving more teachers in the development of mathematics curriculum. The responses of teachers to item 1 were classified according to themes.

(a) School based curriculum committee: Schools should establish consultative committees whose task it is to gather the views of mathematics teachers and submit them to the local curriculum committee who will in turn take them to regional committees and then to the National Curriculum Development Panel. In this way, suggestions provided by the teachers will be incorporated in the adopted mathematics curriculum at the meeting of the National Curriculum Development Panel.

(b) Conferences and symposia: Teacher participation in curriculum development could be advanced if annual conferences and symposia for mathematics teachers are held. At these symposia teachers could raise issues of importance which the mathematics curriculum development officer could note and submit to the National Curriculum Development Panel for incorporation in the mathematics curriculum.

(c) Local and regional mathematics curriculum committees: A forum should be created where mathematics teachers could raise issues they think should be addressed. Such a forum should include both local and regional curriculum development committees who will, after the forum, workshop teachers in their respective schools.

Item 2 asked respondents to identify the teacher's role in mathematics curriculum development

Table 1: Respodents answer to teacher's role in mathematics curriculum development

Teachers' role in Mathematics	Number of Teachers
a) Write books for secondary schools	2
b) Evaluate mathematics syllabus in Botswana secondary schools	4
c) Organize school based workshops	2
d) Organize Mathematics Contents	6
e) Help teachers on how to teach some topics (e.g. probability)	4
f) Implement mathematics topics at classroom level	30
g) Mark national mathematics examination	12

N=60

Item 3 asked respondents to explain the extent of teachers' involvement

Table 2: Respodents answer to the extent of teachers' involvement

The extent of involvement	Number of teachers
a) Not involved at all	8
b) Not much involvement	16
c) Very little involvement	20
d) Very much involvement	6
e) Too much involvement	4
f) Never involved	0

N =60

Stages/phases of curriculum development in which teachers are actively involved

Item 4: asked respondents to identify the stages of curriculum development in which teachers are actively involved.

Table 3: Respodents answer to the stages of curriculum development

Stage of curriculum development	Number of teachers
a) Decision making stage	0
b) Developmental stage	0
c) Trial stage	8
d) Dissemination/diffusion stage	0

e) Adoption stage	0
f) Implementation stage	52
g) Evaluation stage	0

N =60

Item 5 asked respondents to identify the extent of teachers' contribution to curriculum development. Response to item 5 was divided into two categories: those who had contributed and those who had not contributed.

Contributors

We contributed on some topics which have been dropped out of the current BGCSE mathematics syllabus. We asked one of the panel members to in turn ask the curriculum development education officer to include topics such as sets theory and matrices as part of core syllabus. We feel these are very important to students who want to study mathematics at higher levels of education. We have also asked for more topics on gradient. As it is now there are not enough. We would also like to see more topics on 'proofs' as these will promote students' problem solving skills.

Lastly, we asked our representatives to ask our curriculum development officers to check if our mathematics syllabus is on par with those of SADC (Southern African Development Communities) member countries.

Non-contributors

We can only contribute if we are members of the national mathematics panel. Curriculum development officers do not think we can make useful contributions because we are not specialists. They think they are experts so they do not need any input.

Item 6 asked respondents to identify teachers with posts of responsibility who are actively involved in the development of senior secondary school mathematics curriculum.

Table 4: Respodents answer to teachers with posts of responsibility involved in curriculum development

Teachers with posts of responsibility involved in curriculum development	Number of teachers
a) Senior teachers	10
b) Heads of math department	16
c) Head teachers	5
d) Panel members	29

N =60

Item 7 sought to identify curriculum activities in which more teachers are involved.

Table 5: Respodents answer to curriculum activities teachers are involved

Curriculum activities teachers are involved with	Number of teachers
a) Attending workshop on the development of new syllabi	10
b) Participating in the production of new teaching materials for schools	4
c) Reviewing and evaluating mathematics syllabi	0
d) Marking final national mathematics examination	36
e) Team teaching with experienced teachers	10

N =60

Item 8 asked respondents to identify whether teachers studied curriculum development as a mathematics education course in their pre-service training. The responses to this item were divided into yes and no answers. The yes responses were then divided into four parts as follows:

(a) Writing down the objectives: Our lecturers focused on the writing down of objectives. We learned about behavioral objectives and aims. We practiced writing lesson plans in which we wrote specific objectives.
(b) Curriculum evaluation: We looked at what curriculum evaluation is, what its phases are and what it means in the context of Botswana.
(c) Curriculum implementation: We studied curriculum implementation and what a centralized curriculum system is.
(d) Components of curriculum: We did something about Ralph Tyler. All those things, we can't remember them well.

The no responses were divided into the following three parts:

a) Methods of teaching: We concentrated on methods of teaching. We were taught different methods of teaching. There was no time for curriculum
b) Not part of our programme: Curriculum development was not part of our programme. We did not have a course in this area.
c) Lecturers' interest: I think it depends on lecturers' interest. Our lecturers were not interested in this area, maybe they did not value it. We did things like the psychology of learning mathematics, that is we learned that children use different learning styles to learn mathematics. That was useful to us.

Item 9 sought information from respondents on whether the adoption of a centralized curriculum system by Botswana was a good decision. The responses to this question were divided into two parts yes and no. The yes responses were then divided into four parts as follows:

(a) Resources: It helps to distribute resources equally amongst schools. No school should get more books than others.
(b) Transfer: It helps if students are learning the same material at different schools, especially if they need to transfer. For example, if a Form 4 student transfers from Swaneng to Naledi he/she would not have problems because she/he will use the same text book, in a term and will be taught the same topics. Likewise, if a teacher transfers from one school to another, during the term, and was teaching 'Changing the subject of the formula', he/she will still teach the same topic in the new school.
(c) National Examination: Students write the same national examination, so in that way we know they are of the same standard in regard to subject matter. In addition assessment is fair and consistent.
(d) Quality curriculum: It eliminates arguments on what to include or to exclude from the syllabus. The syllabus is of high quality because it contains topics agreed upon by experts.

The 'No' was divided into four parts as follows:

(a) Teacher creativity: I think it blocks teacher creativity. Teachers do not have the freedom to teach what they think will be useful to students and as such the standards of education cannot be raised. There is no freedom in this kind of a system. If a teacher feels she/he can help students understand simultaneous equations better when she/he uses matrices to solve simultaneous equations, he/she cannot do so, unless his/her students are doing Additional Mathematics.
(b) Individual differences: It fails to cater for different abilities. We teach the same concepts to all students yet we know that they are of different abilities; we have high fliers, good ones, slow ones, poor ones, etc
(c) Subject matter: The content we teach is not beneficial to all students. Students who do not value the content we teach tend to see mathematics as a waste of time.
(d) Rigidity: This system is too rigid. Some concepts that are outdated are still being taught. This rigidity is a problem because teachers who would like to include new concepts cannot do so. If they introduce something new, it means they have broken the educational constitution of the country.

Item 10 sought information from the respondents on the importance of teachers' involvement in curriculum development. The responses to item were divided into yes and no. The yes responses were then divided into three parts as follows:

(a) Ownership: Teacher involvement in curriculum development will facilitate the implementation process because they feel they 'own' the curriculum. Without adequate participation, the chances of successful implementation will be greatly reduced.

(b) Professional development: Teachers feel they grow professionally if they are involved. In other words, genuine involvement will enhance teachers' professional growth, independent thinking, and learning through the committees where issues are debated, and as a result they will become true agents of change
(c) Commitment: When one is involved in the development of a curriculum, one becomes committed to it and will make sure that it works. An implementation of a curriculum will work if teachers were involved because they will not only implement it, but defend it as well.

The no responses were divided into two parts as follows:

(a) Limited Training: We have not been well trained as curriculum developers. We have very little knowledge of curriculum development processes, so we may not be of great help. Leave curriculum development to those who are trained as curriculum specialists.
(b) Limited time: Most of our time is spent on teaching, so where would we find time for curriculum involvement? We can't all be involved, so let those with time be involved. If too many teachers get involved, there will be a waste of time on arguments, some of which may not be useful. We are ok with the current system.

Item 11 sought information from respondents on the possibility of including Arithmetic, Geometric Progressions, Binomial Theorem, and Differential and Integral Calculus on the Botswana Senior Secondary Mathematics Syllabus. The responses to this item were divided into yes and no. The yes responses were then divided into three parts as follows:

(a) Strong mathematics foundation: These topics will lay a strong foundation for students who want to study mathematics at institutions of higher learning. Our students have problems in mathematics at the university level and they struggle to understand some concepts. These will help them a lot.
(b) Problem Solving: These topics/concepts will broaden students' knowledge of mathematical concepts. In addition, they will promote problem solving skills and will enhance students' thinking processes.
(c) On par with mathematics syllabi in other SADC countries: The teaching of these topics will help our students to experience fewer problems when they study in other SADC member countries. The gap between our students and students from SADCC countries will narrow.

The no responses were divided into two parts as follows:

(a) Hard for our students: We have very weak students so these topics will frustrate them.
(b) Not useful to all students: These topics are only useful to students who want to study mathematics at the university level, but they are not needed by those who are not interested in higher mathematics

Item 12 sought information from respondent that could be used to strengthen our senior secondary school mathematics syllabus. The responses to this item were categorized as follows:

(a) In-service training: We need thorough in-service training. This will expose us to current subject matter and current theories of learning. A strong knowledge of current subject matter will help us improve our mathematics syllabus.
(b) Software mathematics programmes: We believe that each and every school should be provided with computer mathematics software. This will help to enhance understanding of some concepts. Computer mathematics software programmes can help students learn mathematics with greater understanding.
(c) Annual SADC Mathematical conferences: The European countries hold mathematics conferences annually where they exchange ideas on how to teach some difficult topics. They also help each other by discussing how the teaching of mathematics for senior secondary school students could be improved. At these conferences, teachers learn from each other. They learn instructional strategies that can enhance understanding. Perhaps the SADC member countries could do the same and this would enrich their Mathematics curricula.

DISCUSSION OF RESULTS

This study examined the roles played by teachers in the development of mathematics curriculum. Responses of participants suggest that they are ready to participate in the development of senior secondary school mathematics

curriculum, but are hindered by a variety of factors, namely the organizational structure of the curriculum development department, the criteria used to select participants, and the model of curriculum development employed by Botswana.

Teachers reported that they could be involved through school-based curriculum development committees, and local, regional and national mathematics curriculum panels (Shkedi, 1996). They asserted that if school-based curriculum committees were formed, every mathematics teacher would have the opportunity to be involved. Local curriculum committees could then be formed by selected teachers from school-based curriculum committees. In turn, teachers from the local committees could form a regional curriculum committee and teachers from the regional committees could be selected to join the national mathematics curriculum development panel. In this way, the issues reported at each level of participation would truly represent the views raised by teachers in their respective curriculum committees. Teachers reported that such a structure does not exist in Botswana. They argue that if such a structure was adopted, a quality mathematics curriculum could be achieved. Teachers reported that the establishment of school-based, and local and regional committees would enhance teachers' knowledge and foster the expertise needed in curriculum development. The establishment of school based, local and regional curriculum development committees would give teachers the dignity, respect and recognition they deserve. There was also a general feeling amongst teachers that the launching of conferences and symposia on curriculum development would boost teacher confidence and expertise in curriculum development.

Literature suggests that teachers play many roles in the development of mathematics curriculum (Lloyd, 2004, Clarke, 1999). In this study the participants complained that they are not involved in all the stages of curriculum development, and only enter into the process at the implementation stage (Harding, et al, 1976). The concerns raised by teachers are supported by the results of items 2, 3 and 4. Teachers are developers, designers and planners, yet they are not active in curriculum development.

According to the participants, Head Teachers and Heads of Department often choose teachers that they like to participate in curriculum development irrespective of their strengths and the contributions they will make. Such an activity could frustrate active and young mathematics teachers who are still enthusiastic. Nisbett (1976) concurs that young teachers tend to contribute more in professional meetings and curriculum development committees. He asserts that they do not fear innovation and that "it is hardly surprising that younger and less experienced teachers are usually the strongest advocate of reforms, they have as it were, the least to lose" (p,3).

The results of this study indicate that teachers who are actively involved in curriculum development are those with posts of responsibility (item 6). Those who hold posts of responsibility such as *senior teachers*, *heads of mathematics department* and *members of the national mathematics panel* are chosen to be involved in curriculum activities. The extent of teacher involvement in other curriculum activities as shown in item 7 indicates that a large number of teachers participate in the marking of the BGCSE (Botswana General Certificate of Secondary Education) national examination.

Some participants indicated that they completed a mathematics curriculum development course in their pre-service training while others reported that they have not participated in such a course. Those who had done a curriculum development course gave responses that revealed an understanding of what curriculum entails. At the same time, there were also some who conceptualized curriculum only as a product and not as a process as well. The participants who reported that they have not done curriculum development in mathematics seemed not to realize that methods of teaching currently used in schools are a product of the curriculum. In other words, the philosophy of the curriculum influences how its concepts are going to be taught. Some participants reported that they learned something about the psychology of learning mathematics.

With regard to the centralized system, participants were of two views. There were those who supported a centralized curriculum and those who objected it. Reasons for supporting the adoption of a centralized curriculum included equal distribution of resources amongst schools, ease of transfer of both students and teachers, writing of the same national examination and maintaining the same standard of education in the country. Those who objected to the adoption of a centralized curriculum argued that it blocks teacher creativity, retards professional developments, fails to cater to students' individual differences, teaches contents that may not be beneficial to all students, and contains a rigidity which allows outdated concepts/ topics to be taught.

In a centralized system, governments can issue directives saying, for example, "from the 1st of January, 1968, all schools in Botswana shall use the Modern Mathematics Syllabus" (Mosothwane, 1982; Howson, et al, 1981). In this instance, the Ministry of Education used its authority to impose an innovation on its subordinates (teachers). This coercive strategy tends to put more pressure on the teachers who are to implement the new curriculum. Nonetheless, some participants supported the legitimacy of a centralized curriculum saying it unites the nation and so cannot be completely eradicated.

Ideas from both supporters and non-supporters can be used to develop a quality mathematics curriculum. Some teachers reported that education officers can abuse a centralized system by removing some topics from the curriculum that

are crucial for learning mathematics. For example 'Set Theory and Matrices' have been removed from the core syllabus of senior secondary school mathematics. Teachers argue that probability cannot be fully understood by students without set theory, yet probability is part of the core syllabus when set theory is not. The realization by teachers that some much needed topics have been removed from the core BGCSE mathematics syllabus suggests that their participation in curriculum development is minimal. If teachers were fully involved from the outset, they would have played the role of a diagnostician by identifying the conspicuous absence of some topics and thus remedying the gaps created.

Different scholars have reiterated the importance of teacher involvement in curriculum development (Saban, 2004; Young, 1998; Penney & Fox, 1997; Diphola, 1995). These scholars contended that participation increases teacher confidence, commitment, and ownership. In this study, teachers mentioned factors that hinder their participation as limited training, limited time and the fact that much of their time is spent on teaching. They have, thus, not been empowered to engage in curriculum activities. Teachers as diagnosticians have realized that some very able students are denied or hampered by the exclusion of some concepts from the core syllabus of BGCSE. They contended that the inclusion of calculus, binomial theorems, and geometric and arithmetic progressions would lay a strong foundation for learning mathematics at the university level. Those who objected to the inclusion of arithmetic and geometric progressions, binomial theorem, and differential and Integral calculus in the core syllabus of the BGCSE contended that these would create more problems for students. These teachers suggested that senior secondary school students may require two different kinds of mathematics syllabuses as is the case in South Africa. South Africa has Mathematics Standard Grade, taken by all students, which includes calculus, and Mathematics Higher Grade taken by students of high ability.

CONCLUSION

The observation that teachers' role in curriculum development is limited should not be surprising. Literature shows that in a centralized system, curriculum development is done at the exclusion of teachers. Only a few teachers are able to be involved and these are the ones who hold post of responsibilities. Establishing school-based, local, regional and national curriculum development panels would enhance teacher participation. Through these committees, the expertise of teachers could be accessed and contribute to a quality mathematics curriculum that would strengthen mathematics education across Botswana.

An analysis of literature suggests that most educators advocate for increased teacher involvement in all stages of curriculum development as a way to improve curriculum. Carl (2009) reported that without adequate participation, the chances of successful implementation are greatly diminished. Furthermore, it has been found that lack of participation may lead to misconceptions of what is expected. Greater participation may also lead to greater job satisfaction (Carl, 2009).

RECOMMENDATIONS

Since one of the major roles of teachers is that of developers, it is recommended that curriculum development committees be formed at school, local and regional levels, so that those who are chosen for national panels present views that truly represent those of teachers at the three levels. It is not expected that all teachers would participate directly, but their ideas and those from curriculum development education officers combined would lead to the production of a quality mathematics curriculum.

A centralized curriculum (a curriculum under the control of the central government) should still be maintained since it helps to distribute resources equally amongst schools, ease the transfer of students and teachers between schools, and ensure that the implementation of a new curriculum can easily be monitored.

Since curriculum development education officers play a leading role in the development of mathematics curriculum they should possess both subject matter knowledge (SMK) and pedagogical content knowledge (PCK). A combination of both SMK (Cognate) and PCK (Instructional Strategies) would produce competent and knowledgeable education officers who would drive curriculum reforms towards a quality curriculum for Botswana senior secondary schools. Harding, Kelly and Nicodemus (1976) have developed a model that shows all the stages inherent in curriculum development in which teachers should actively participate if a quality curriculum is to be achieved. This model is recommended for Botswana and can be seen in Appendix A.

REFERENCES

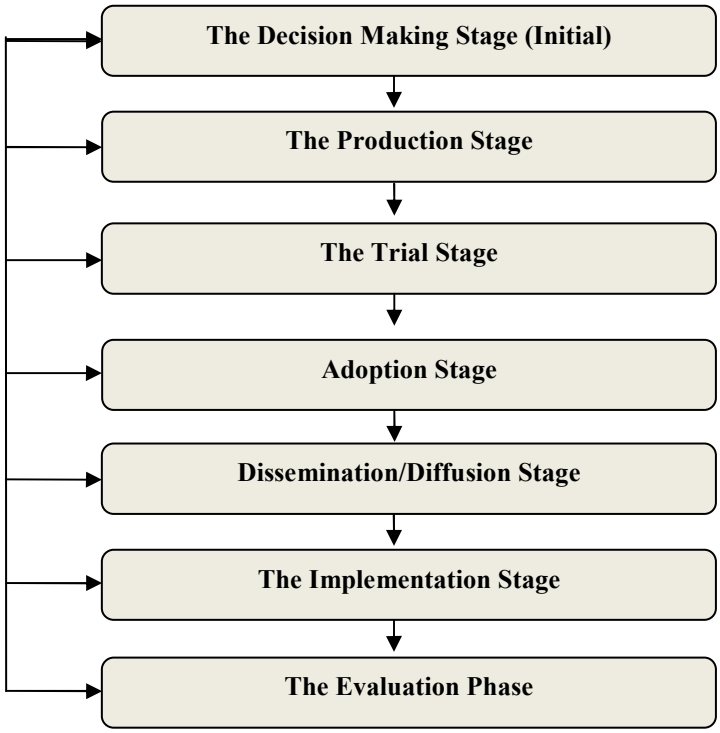
Bayona, E. L. M. (1995). *Curriculum design and development: the role of teachers*. Gaborone: Lentswe La Lesedi

Bol. L., & Berry III, R.O. (2005). Secondary school mathematics teachers' perceptions of the achievement gap. University of North Carolina.
Carl, A. E. (2009) *Teacher empowerment through curriculum development: Theory into practice* (2nd Ed.) Cape Town: Juta.
Clarke, M. (1997). The changing role of the mathematics teacher. *Journal for Research in mathematics Education*, *28*(3), 278-308.
Corno, L. (1977). Teacher autonomy and instructional systems. In L. Rubin (Ed.). *Curriculum handbook: administration and theory* (pp. 234-245). Boston: Allyn & Bacon.
Diphofa, M. (1995). Teacher participation in curriculum development: Views from the ground. *Multicultural Teaching*, *13*(3), 35-40.
Eggleston, J. (1977). *The sociology of the school curriculum*. London: Routledge and Kegan Paul.
Graven, M. (2002). Coping with new mathematics teachers' roles in a contradictory context of curriculum change. *The mathematics Education 12*(2), 21-26.
Gray, J, & Campbell-Evans, G. (n.d). *Beginning teachers as teacher-researcher*. University of North Carolina.
Gooya Z. (2007). Mathematics teachers' beliefs about a new reform in high school geometry in Iran. *Educational Studies Mathematics,* 65, 331–347
Harding, J. M., Kelly, P. J., & Nicodemus, R. T. (1976). The study of curriculum change. *Studies in Science Education*, *3*, 1-30.
Hermsen, A. (2000). Participatory curriculum development in practice: An experience at Eastern Caribbean Institute for Agriculture and Forestry in Trinidad and Tobago. Retrieved August, 1, 2011 from http://w.w.w.fao.org/sd/Exre0030htm.
House, E. (1977). The macropolitics of innovations: Nine propositions. In P. Hughes (Ed.), *The teacher's role in curriculum design* (pp.1-9). Sidney: Angus and Robertson.
Howson, G., Keitel, C., & Kilpatrick, J. (1981). *Curriculum development in mathematics* .London: Cambridge University Press.
Hunkins, F. P. (1972). New identities for new tasks. *Educational Leadership* 29(6), 503-506.
Lloyd, M. (2004). Two teachers' conceptions of a reform-oriented curriculum: Implications for mathematics teacher's development. *Journal of Mathematics Teacher Education, 1*, 227-252.
Marsh, C. J. & Stafford, K. (1988). *Curriculum-practices and issues* (2nd Ed.). Sydney: McGraw –Hill.
Mosothwane, M. (2008). The dynamics of curriculum reform in Botswana with special reference to mathematics education. Unpublished paper, University of Botswana, Gaborone.
Mosothwane, M. (1982). The role of Botswana mathematics teachers in the construction of mathematics curriculum. Unpublished dissertation (DAES). University of Newcastle Upon Tyne.
Nisbett, J. (1976). Contrasting structures for curriculum development: Scotland and England. *Journal of Curriculum Studies 8*, 167-170.
Nunam, T. (1983). *Countering education design.* London: Croom Helm.
Penney, D & Fox, B. (1997). At the wheel or backseat driver? The role of teachers in contemporary curriculum reform. *Queensland Journal of Educational Research 13*(2), 14-27.
Republic of Botswana, (1996). Guidelines for curriculum subject panels. Ministry of Education, Department of Curriculum Development and Evaluation.
Saban, A (2004). Outcomes of teacher participation in the curriculum development process. *Education, 115*(4), 571-574.
Sack, J. J. (2008). Common place within a high school mathematics leadership institute. *Journal of Teacher Education*, *59*(2), 189-199.
Shkedi, A. (1996). School-based workshops for teacher participation in curriculum development. *Journal of Curriculum Studies, 28*(6), 699-711.
Skilbeck, M. (2005). *The school based curriculum development,* (3rd Ed.). Netherlands; Springer.
Skilbeck, M. (1984). *The school based curriculum development*. London: Harper & Row.
Swartland, J. (2003). Curriculum development in mathematics education in Botswana. Personal Communication, April 18, 2003. Gaborone.
Taylor. P. (2004). *How can participatory processes of curriculum development impact on the quality of teaching and learning in developing countries*. Paris: UNESCO.
Tiro, A., & Macholo, T (2002). The curriculum and special needs. A report on the proceedings of the Recommendation of 122 held at Marang Hotel-City of Francistown, 7-9 August. Francistown, Botswana.

Wright, C. (1995) Towards a policy for basic education. Ministry of Education, Curriculum Development and Evaluation. Gaborone, Botswana.
Young, J. (1998). Teacher participation in curriculum development: what status does it have? *Journal of Curriculum and Supervision, 3*(2), 109-121.

Appendix A

Stages inherent in curriculum development



Adapted from Harding, et al, 1976

---

[i] Dr. Modise Mosohtwane is currently an Associate Professor in Science and Environmental Education and Biology Education in the Department of Primary Education, University of Botswana. He holds a B.Ed (Honours) in Biology and Mathematics, Southern Queensland in Australia, M.Ed in Mathematics Education, Keele University in Britain and PhD in Science and Environmental Education and Biology, UGA in the US.