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An exploration of the Relevance of the Pedagogy and Academic Content Knowledge that are Offered to Prospective Science and Mathematics Teachers in Tanzania Teachers' colleges

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Abstract

This paper explored the Relevance of the Pedagogy and Academic Content Knowledge that are offered to Prospective Science and Mathematics Teachers in Tanzania Teachers' colleges. Morogoro Teachers' College and Kleruu Teachers' college were used as a case study. The performance in science and mathematics subjects in form four National examinations for four years consecutively are poor.There is doubt whether the pedagogy and academic contents offered to prospective science and mathematics which are stated in curriculum framework of teacher education and subjects syllabuses in secondary school are relevance. The study employed qualitative approach with a case study design. Key informant interview, focus group discussion and documentary review were the main methods of data collection whereby 32 respondents were involved in data collection. Content analysis was used to analyze data thematically. The study found that the academic content knowledge that is offered is of minimal relevance as most of the topics are too advanced and they do not reflect what is taught in secondary schools. Unfamiliarity and complex topics to college tutors such as computer packages in mathematics were also revealed.

Keywords: Academic Content Knowledge, Pedagogical Content Knowledge, Teachers' college, Prospective science and Mathematics teachers, student teachers, syllabus

1. Introduction

Professionally and academically qualified science and mathematics teachers have to exert a lot of efforts to develop and reinforce their students' learning and creative thinking (Mahmood, 2001). This is because, well qualified and competent teachers have critical roles to play in promoting and simplifying the process of imparting knowledge to students by considering their cognitive development during training and actual practice during the teaching and learning process. This cannot be realised without having a package of knowledge stated in their curriculum framework and in syllabuses. This implies that the content that need to be offered to them before graduation must be valid and relevance to what they will teach after graduation; that is, the delivering of subject matter knowledge and use of different instructional processes (that is good use of pedagogy) (Mahmood, 2001). One of the reasons that have caused poor performance in science and mathematics in most secondary schools in Tanzania is suspected to be the poor quality of the teachers, who are poorly prepared in terms of subject matter content and the pedagogical skills during training in the teachers' colleges. For example consider table 1.1 hereunder.

Table 1.1: **Pass rate in form four examinations (CSEE) in science subjects and mathematics from 2009-2014**

Subjects	Performance in Years by Pass Rate (%)					
	2009	2010	2011	2012	2013	2014
Mathematics	17.8	16.1	14.6	11.3	17.8	19.6
Biology	43.2	30.5	43.1	30.5	37.1	48.3
Physics	55.5	44.6	43.2	42.5	44.1	46.7
Chemistry	57.1	43.9	43.3	46.0	50.2	56.7

Source: BEST (2009-2015)

Table 1.1 shows the pass rate of science and mathematics from 2009 to 2014 which evidenced on how science and mathematics subjects were performed poorly in form four national examinations. Moreover, the performance in mathematics and biology subjects seem to be poorer compare to other science subjects namely physics and chemistry although the last two years, the performance raised a little compared to previous years due to the Big Results Now (BRN) policy.

1.1 Pedagogy Content Knowledge (PCK) and Academic Content Knowledge (ACK)

During training, the student teachers are equipped with the knowledge and skills of the subject matter (academic content) and methods of teaching subject (pedagogy content) during the theory part in the college. Apart from that, student teachers are also equipped with professional courses, for example, Educational Psychology and Counselling, Foundations of Education, Educational Research and Measurement, Evaluation and Curriculum; and general courses for example Development Studies, Information and Communication Technology, Educational Media and Technology, Communication Skills, Projects and Religion (Komba and Kira, 2013;TIE, 2007). The curriculum for teacher education programs in Tanzania, for instance the subject syllabuses for science and mathematics at diploma level have stated that all PCK and ACK have to be provided to the prospective teachers during their training in colleges such as academic courses and teaching methods, professional courses and general courses (TIE, 2007). The academic contents are offered in terms of subject specialization such as physics, chemistry, biology and mathematics. The academic content in the curriculum framework are named as core subject I and core subject II (content/ACK I & II) as every student teacher is required to take two subjects of his/her specialization. The aim of providing academic content is to improve student teachers' academic competence of the teaching subject which is the same in all countries according to Shulman (1986). For each academic year there is provision of knowledge on pedagogy which aims at developing the methods, strategies and techniques which should be used in the teaching and learning of the academic subjects by the prospective teachers (TIE, 2007). In the professional and general courses offered to student teachers during training, they learn how to apply theories learned from educational foundations, educational psychology, principles of curriculum development and evaluation, and instructional technology (Komba &Kira, 2013).

The provision of pedagogy and academic content knowledge to science and mathematics student teachers in the college aims to help the student teacher to prepare lesson plans, make presentations of subject matter, including appropriateness of teaching methods, effective use of teaching and learning resources, to conclude lessons and ability to manage classrooms (Komba & Kira, 2013). Some studies that had been conducted in Tanzania on prospective science and mathematics teachers revealed that during their teaching practice exercise they found to have low mastering of subject matter knowledge during presentation, also they had no knowledge on preparation of the lesson plan as it was difficult to state instructional objectives (Mbunda, 1992). Moreover, in a study by Mosha (2004) in Dar es Salaam it was revealed that during preparation of PCK, there is insufficient time allocated to cover content and pedagogy as well as professional skills which are essential for effective teaching for prospective teachers. In Tanzania the preparation of science and mathematics student teachers in terms of pedagogy and academic content follow the curriculum framework of teacher education which is prepared by the Tanzania Institute of Education (TIE). According to TIE (2007), the science and mathematics student teachers are prepared not only in academic and pedagogical content but also in other courses such as professional and general courses in order to sharpen their teaching professions. The purpose of provision of the academic course is to improve science and mathematics student teachers' academic competences on teaching subjects and the pedagogical course is to equip the student teacher with the knowledge on different methods, strategies and techniques used in the teaching and learning of the academic subjects (TIE, 2007).

Therefore, the studies which have been provided showing the problems on pedagogy and academic content in Tanzania together with the performance of science and mathematics in National form four in secondary schools in table 1.1, it shows that there is a problem on the pedagogy and academic content offered to prospective science and mathematics teachers in Tanzania teachers colleges. Hence this study aimed to explore relevance of the pedagogy and academic content knowledge offered to prospective science and mathematics teachers during training in the teachers colleges.

2. General and specific objective

The general purpose of this study was to explore the relevance of the pedagogy and academic content knowledge that offer to prospective science and mathematics teachers. Specifically the study intended to explore the relevance of the academic content that are offered to prospective science and mathematics teachers as well as the relevance of the pedagogical content that are offered to prospective science and mathematics teachers in Tanzania teachers' colleges. The specific objectives followed by the key research questions which were:

i. To what extent do the academic content knowledge relevant to prospective science and mathematics teachers?

ii. To what extent do the pedagogy content knowledge relevant to prospective science and mathematics teachers?

3. Literature Review

3.1 Relevance of Pedagogical and Academic Content Knowledge to Prospective Science and Mathematics Teachers

Shulman (1986) defined Pedagogical Content Knowledge (PCK) as teachers' interpretations and transformations of subject-matter knowledge in the context of facilitating student learning. He further proposed several key elements of pedagogical content knowledge which are: content knowledge, which is the knowledge of representations of subject matter. Second is the knowledge of understanding of students' conceptions of the subject which is knowledge of the learner that prospective teachers are supposed to know, and the last is the teaching strategies which are associated with different specific subject matter that can help prospective teachers to implement their teaching well in the classrooms. Subject matter content and pedagogical knowledge are central to the teaching profession of prospective teachers (De Leon, 2000).

Knowing what to teach is the basis for knowing how or what teaching methods to be used for effective teaching. Knowing how without knowing what to teach is likely to become a threat in the teaching profession hence the prospective science and mathematics teachers need to be prepared in both subject matter content and pedagogical content knowledge (De Leon, 2000). In teacher education and training institutions they have to pay attention to the equilibrium between pedagogy and subject content.

Darling–Hammond (2005) in her conceptual framework argued that student teachers should understand how to teach the children by having deep knowledge of subject matter, pedagogy and social context before they start to practice teaching, for example methods to deliver subject matter, knowledge of the learner and the learning environment. Teachers who are well equipped with the subject matter content and pedagogical knowledge are likely to deliver worthy stuff to the learners as the mastering of the subject matter content is essential for effective teaching (Allen, 2003; Walsh & Sanders, 2004). Inadequate knowledge of subject matter content and pedagogical knowledge on the part of the teacher after the training is the main hindrance in the classroom interaction. Pedagogical content knowledge depends heavily on conceptual understanding of the subject matter (Bransford, Brown & Cocking, 1999).

Shulman (1987) argued that teachers need to have deep knowledge or understanding of their subject matter and how to make it accessible to others. Making content accessible to others lies on understanding of students' prior knowledge and experience and understanding of the learning process. Deep understanding includes understanding the knowledge, purposes, methods and forms of subjects. Pedagogical content knowledge includes the knowledge of how to explicate particular concepts and how to demonstrate and rationalize procedures and methods of teaching given content (Gardner, 1991). Also it helps on how to correct theories and misconceptions about the subject matter (Sternberg & Horvath, 1995). Preparation of student teachers in PCK in United States of America served to re-focus student teachers' attention on the important role of subject matter in educational practices (Gess-Newsome & Lederman, 2001).

The preparation of student teachers on PCK received its special focus not only in U.S.A but also in other countries, for example the Netherlands, Britain and Australia (Shanahan & Shanahan, 2008). Pedagogical content knowledge (PCK) has been suggested as one knowledge base for science and mathematics teacher preparation and it could be an alternative perspective from which science educators could view secondary science teacher preparation (Anderson & Mitchener, 1994). PCK should also focus on technology where the student teachers should be prepared well in Technological Pedagogy Content Knowledge (TPCK) (Koehler & Mishra, 2008). TPCK emphasizes the comprehensive set of competencies teachers need to successfully integrate

technology in their educational practices. The key to TPCK is the integration of multiple domains of knowledge in a way that supports teachers in teaching their students the subject matter with technology (Niess, 2005).

3.2 Knowledge gap

Many studies have been conducted in different countries including Tanzania on teacher education in general. There is no study conducted so far to specifically explore the relevance of the pedagogy and academic content knowledge that are offered to prospective science and mathematics teachers in Tanzania teachers' colleges. This study aimed to fill the gap

4. Methodology

4.1 Study area

This study was conducted at Morogoro and KleruuTeachers' colleges which obtained through simple random among 7 public teachers' college offering science and mathematics education. The public colleges were taken as they are the one which enroll many student teachers compared to private colleges. for example in 2011 there were 25,814 student teachers in public teacher training colleges and 10,834 in private teacher training colleges which made a total of 36,648 student teachers from both public and private teachers' colleges (MoEVT, 2011). 8 college tutors and 24 science and mathematics student teachers were purposively selected.

4.2 Research design and data collection

The study employed a qualitative research approach where a case study research design was used. Qualitative data on the relevance of pedagogy and academic content knowledge that are offered to prospective science and mathematics teachers were collected by using key informant interviews, focus group discussion and documentary review. The curriculum frame work for teacher education in Tanzania, science and mathematics syllabuses both for diploma and secondary school were reviewed.

4.3 Data analysis

Content analysis was used to analyse data which were obtained through interviews, focus group discussions and documentary review. In depth descriptions of specific themes based on research objective and related question was provided as most of the data were in form of word.

5. Results and discussions

5.1 Relevance of the Academic Content Knowledge to prospective science and mathematics teachers

In order to understand the academic content offered to the student teachers and its relevance to them, a content analysis of the 2009 syllabuses for both mathematics and biology subjects that is offered at diploma level was done, the same was done with particular regard to mathematics and biology syllabuses for the secondary school of 2005 where the student teachers are expected to go and teach after graduation. The new syllabuses of 2009 were introduced into the teacher training colleges after the introduction of Competence Based Curriculum (CBC) in Tanzania in 2005 for secondary schools. The content in the syllabuses are prepared by the Tanzania Institute of Education (TIE) with other education stakeholders.

Findings from the analysis showed that the mathematics and biology syllabus for diploma level had 12 topics and 6 topics respectively of which have to be covered in two years. The aim of teaching academic content is to improve student teacher academic content competence of the teaching subject in which they are specializing in. The relevance of the academic content in teacher colleges is to be judged by looking at the topics selected to be taught during training and the expected topics to be taught in secondary schools for which they are prepared for. Table 5.1 and 5.2 provides the summary of the topics to be covered by student teachers in mathematics and biology respectively and including the expected topics to be taught in secondary schools.

Table 5.1**: Mathematics Topics Taught in Teachers College and the Expected Topics to be taught in Secondary Schools**

Subject	Topics taught at Teacher training colleges (Syllabus 2009)	Topics expected to be taught in secondary education (O-level) according to 2005 syllabus
Mathematics	Similarity and congruence	Similarity & congruence (form 2)
	Logic	Not applicable
	Calculating device	Not applicable
	Coordinate geometry II	Not applicable
	Linear programming	Linear programming (form 4)
	Probability	Probability (form 4)
	Algebra	Algebra (form 1 & 2)
	Trigonometry	Trigonometry (form 2 & 4)
	Differentiation	Not applicable
	Integration	Not applicable
	Hyperbolic function	Not applicable
	Vector	Vector (form 4)

Source: MoEVT, (2009c) & MoEVT, (2005b)

The data in table 5.1 shows that among the 12 mathematics topics to be covered by student teachers in the training colleges only 7 topics are expected to be taught in secondary school among 38 topics that are present in the ordinary level mathematics syllabus for form one to form four (O' level secondary education). The topics that are taught in teacher training syllabus that are also taught in secondary school with respect to classes include one topic in form one, three topics in form two and three topics in form four as indicated in table 5.1. In a more logical form, it could have been wise to include topics that cut across all the class levels with equal proportion, or with increasing number according to class levels. But according to what is shown in the syllabus, the form three topics are not offered at all to the student teachers in the colleges while they will be required to teach form three during their practice exercise and after their graduation.

Table 5.2**: Biology Topics Taught in Teachers Colleges and the Expected Topics to be taught in Secondary Schools**

Subject	Topics taught at Teacher training colleges (Syllabus 2009)	Topics expected to be taught in secondary Education (O-level) according to 2005 syllabus
Biology	Biochemistry	Not applicable
	Classification of living things	Classification of living things (form 1, 2 & 3)
	Respiration	Gaseous exchange and respiration (form 2)
	The body, health and immunity	Health and immunity (form 1)
	Genetics	Genetics (form 4)
	Ecology	Balance of nature (form 2)

Source: MoEVT, (2009a) & MoEVT, (2005a).

Data in Table 5.2 shows that among the 6 biology topics provided by the college syllabus during training, 5 topics are taught in secondary schools with exception of only one topic which is biochemistry; this topic is not expected to be taught in ordinary level biology syllabus. On top of that, many biology topics in teachers colleges relates to the topics in biology in secondary school syllabus but the problem is that most of them are too advanced compared to what they are going to teach in secondary school syllabus. Since the other Biology topics in teacher colleges do not correspond with the topics to be taught in secondary schools for which they are prepared together with its advanced and its complexity then the findings imply that most of the amount of academic content offered to student teachers is minimally relevant to what they would practice in secondary schools as prospective teachers.

These findings were also supported by the tutors' interview responses and student teachers in focused group discussions, where 5 out of 8 tutors indicated that most content offered to prospective biology and mathematics student teachers do not exactly reflect what is going to be taught in secondary schools, this is partly because some topics are too advanced compared to the topics which are taught in schools. They argued that it could be

possible that these topics were included to prepare the student teachers with the advanced knowledge level as they prepare themselves with their final examinations in teacher colleges and not what they were actually going to teach after completion of the college. For example, topics on logic, differentiation, integration, hyperbolic function in mathematics and biochemistry in biology were too advanced, and could be used in preparing teachers who would teach A-level classes. On the other hand 3 out of 8 tutors viewed that most of the topics offered to student teachers were relevant and have met the required standard as these were also reflected in topics of secondary school syllabuses.

Moreover, during the focused group discussions with the student teachers, the mathematics group argued that some of the topics in the diploma level syllabus were not taught by their tutors due to its lack of applicability in secondary school and being unfamiliar to them, for example, a topic on computer packages in mathematics; this seemed to be contrary as tutors were well qualified and had enough working experiences. Hence, contents to students teachers in terms of subject matter content was not well planned as it has to be realized that the enrolled student teachers come in with very low grades showing they did not score well in their O-level and A-level examinations, and they need to be taken through the courses again so that they leave college competent enough to teach complex concepts in science and mathematics at ordinary level.

The researcher suggested that it could be better if the topics taught to the student teachers in the colleges would cut across from low to higher levels that are O- level and A-level secondary school topics as the student teachers might be required to teach secondary school level after completion and also undergo professional development programs from diploma to degree. For example, in biology the topic of classification in teacher colleges could cover first level one and level two where level one is the classification taught in form one and form three, while level two is the classification which is taught in form two and form four in secondary school before covering the classification which is too advanced in the teachers colleges compared to what would be taught in secondary schools. It has to be realized that an effective teacher should be well prepared in academic content so as to be conversant in the subject matter as it is central to the teaching profession of prospective teachers (De Leon, 2000). The overall objective of providing academic content is to improve student teacher academic competence of the teaching subject.

5.2 Relevance of the Pedagogical Content Knowledge to prospective science and mathematics teachers

In terms of the relevance on pedagogy content knowledge, the researcher assessed the pedagogy content knowledge offered to the prospective science and mathematics teachers in the colleges in both mathematics and biology subjects. The researcher conducted a documentary review in mathematics and biology pedagogy syllabus. These syllabuses were the ones published in 2009 after the introduction of Competence Based Curriculum (CBC) in teachers colleges. The contents in the syllabuses were prepared by the Tanzania Institute of Education (TIE). The mathematics pedagogy syllabus was found to have 5 topics while the biology pedagogy syllabus had 5 topics. Tables 5.3 and 5.4 provide the summary of the topics and their coverage in both mathematics and biology pedagogy syllabuses respectively.

Table 5.3**: Topics in mathematics pedagogy syllabus and its coverage**

No.	Mathematics pedagogy topics	Content coverage
1.	Foundation of mathematics	Meaning and importance of mathematics, principles of teaching mathematics, motivation in teaching and learning mathematics.
2.	Analysis of mathematics curriculum materials	Syllabus analysis, features of mathematics text book and teachers' guide.
3.	Assessment in mathematics	Mathematics test construction, moderation of mathematics test, standardization of test results, keeping record of students in mathematics learning.
4.	Planning and preparation for teaching mathematics	Preparation of scheme of work, lesson plan, T/L methods, T/L resources, mathematics logbook, application of computer in mathematics teaching.
5.	Teaching the selected topics	Preparation for teaching, distance along small circles, distance along great circle, chord properties of a circle, tangent properties, similar figures, domain and range.

Source: MoEVT (2009d).

The data in Table 5.3 show that the topics in pedagogical courses and their content coverage covers all the important pedagogical skills required by the prospective teachers to acquire prior to teaching practice or their teaching profession. Following the coverage of the topics in mathematics pedagogy it shows that the topics were relevant to the student teachers due to the important knowledge and skills which would be provided to the student teachers throughout the course. For example in mathematics pedagogy the topic of analysis of mathematics curriculum materials and the topic of planning and preparation for teaching mathematics in table 5.3 are useful in helping student teachers to analyze syllabus, text book and teacher's guide as well as guiding them to prepare schemes of work, lesson plans and informing logbook. The other topics follow the same sequence of usefulness to student teachers in providing the required knowledge and skills.

Table 5.4: **Topics in biology pedagogy syllabus and its coverage**

No.	Biology topics (pedagogy)	Content coverage
1.	Foundation of teaching and learning biology	Importance of learning biology, principles of teaching and learning biology.
2.	Basic biology laboratory skills	Laboratory management and maintenance, biology laboratory safety and first aid provision, preparation of common laboratory chemicals and reagents, dissection of animals, plant sections.
3.	Analysis of ordinary level biology curriculum materials	Analysis of O-level biology syllabus, analysis of text books, analysis of teachers' guide/manuals, relationship between syllabus, text book and teacher's guide.
4.	Planning and preparation of teaching biology	Preparation of scheme of work, lesson plan, subject logbook, preparation of T/L resources, application of ICT in T/L biology, microteaching and reflection.
5.	Assessment in biology	Construction of a biology test/examination, moderation of biology test/examination, marking of biology test/ examination, standardization of biology test/examination, record keeping of students' progress, assessment of practical.

Source: MoEVT (2009b).

The data in Table 5.4 show the topics in pedagogical courses and their coverage which are offered to biology diploma student teachers in teacher training colleges. It shows that the course provide all important pedagogical skills required by prospective teachers to acquire prior to teaching practice or to teaching profession. Thus, the course seems to be relevant to student teachers during their training. For example in biology pedagogy the topic of foundation of teaching and learning biology in table 5.4 exposes the student teachers to basic principles of teaching and learning biology in secondary schools, also the topic of assessment in biology exposes the student teachers on how to construct biology test/examination, moderate, standardization and keeping the students' record of their progress. The rest of the topics follow the same trend in providing useful knowledge and skills to student teachers. The pedagogical courses seem to be relevant to student teachers in that student teachers should be provided with pedagogical skills before teaching practice which will include knowing different teaching methods, techniques and strategies to be used in a classroom situation, for instance the use of discussions, debates, designing experiments that could be exploratory with an inquiry mind, developing or using simulations and organizing workshops, all these methods are within Tables 5.3 and 5.4 suggesting that the content is enough to student teachers at diploma level.

6. Conclusion and recommendations

From the study it was observed that the academic content knowledge that are offered to prospective science and mathematics teachers are minimal relevant as some of the topics prepared which has to be taught to the student teachers are too advanced and not reflecting the amount and level of what is taught in secondary schools for which they are prepared for. Also the other topics are too complex and unfamiliar to the college tutors to cover during training for example computer packages in mathematics, although tutors are well qualified and experienced. On top of that the pedagogy content seemed to be relevant. The Tanzania Institute of Education should restructure the academic contents offered to prospective science and mathematics teachers in the Teachers' Training College so that the contents can cut across what is taught in secondary schools for which they are prepared. In addition to that, college tutors should undergo professional development for unfamiliar and complex topics.

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