

Training teachers for secondary mathematics and science: The challenge facing University of Malawi

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Background

The development of human capacity in Science, Mathematics and Technology (SMT) has been on the agenda of almost all developing countries over the past few decades. This is in response to the widespread evidence from the developed countries, and more recently, from the experiences of the East Asian Tiger economies, of the positive relationship between SMT and development (Caillods, et al., 1996). In the twenty-first century, two pressing needs further increases this commitment. The first and perhaps most important, is the escalation of poverty in these countries (Watson, et al., 2003; UNDP, 2003). It is believed that SMT could help in poverty reduction through increased agricultural productivity, improved nutrition and health, as well as minimizing environmental degradation, factors aligned with Human Development Index and therefore poverty reduction. The second is the current information and communication revolution with its subsequent globalisation effects

Malawi is one example of a developing country that is committed to SMT human capacity development. Her recent policy initiatives in this regard began with the vision 2020. Launched in 1997, the vision is to change Malawi's economic base from reliance on physical labour to a 'technologically driven economy' (Malawi Government, 1999) through the development of human capacity in SMT, by the year 2020. This vision is reflected in the National Science and Technology policy (Malawi Government, 2001) paper which argues for expansion of university education 'especially in the scientific, engineering and technological fields' (p.22) and institution and expansion of postgraduate programmes. The Malawi Poverty Reduction and Strategy Paper (MPRSP), (Malawi Government, 2002) and more recently, the Malawi Growth and Development Strategy Paper (Malawi Government, 2006), which represent government's blue print for poverty reduction, also echo the need for SMT human capacity development. In line with the Science and Technology Paper, the MPRSP argues for expansion of both undergraduate and postgraduate programmes in science and technology. In addition however, the MPRSP calls for improvement of quality and relevance of secondary science education through provision of adequate teaching and learning resources and appropriate review of the curriculum.

Improvement of secondary SMT education is indeed necessary if the expansion of university enrolment in the area is to be achieved. For this to be realised, provision of adequate teaching and leaning resources is important. Such teaching and learning resources include teachers. It is the thesis in this article that teachers are key leverage points in achieving the strategies for poverty reduction through SMT human capacity development. As such, the article examines the current situation regarding the purported adequacy of provision of SMT teachers for secondary education. It discusses the challenges facing the secondary teacher training institutions in achieving the desirable quantity and quality of SMT teachers for the country. It bases its analysis on the University of Malawi, which is the main University in the country and hosting the oldest

and main faculty of education. Selection and graduation statistics for SMT education students are used in the analysis. However, before this is done, there is need to justify why a teacher is central in the teaching and learning situation and consequently human capital development.

The teacher and the teaching and learning situation

In defining the variables of the teaching and learning situation, three interrelated factors have largely been of value in the past. These are the teacher, the student and the context. However, in recent times, these factors have been broadened to include a hexagon of factors: the teacher, goals, content, teaching methods, learners and general conditions as represented in figure 1 (Wessler, 2005).

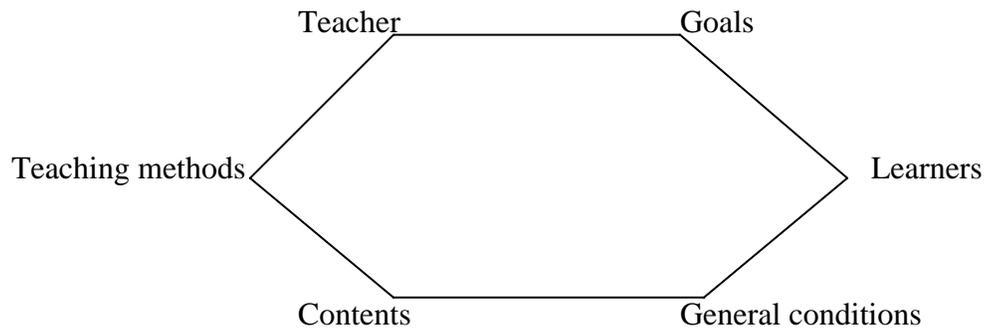


Figure 1. Variables of the teaching and learning environment

- The **teacher** factor includes the beliefs about teaching and learning, the acquired pedagogical skills, values and orientation, the educational preparation and other socio-biographic characteristics.
- The **learner** factor includes the attitudes towards learning, learning goals, motivation, background characteristics and perceptions of good teaching and learning.
- The **goals** are the competences that the course intends to achieve in the students (cognitive, affective and practical)
- The **content** relates to the nature of topics, selection and reduction of what to teach, the general design of the course and the design of specific lessons.
- The **teaching methods** refer to the nature of presentation, variation in use of strategies and level of interaction.
- The **general conditions** include general issues about the learning environment and its academic resources such as the type of rooms, timing of the lessons, equipment, examination regulations and many others.

The argument in this article is that the teacher is a key leverage point in this hexagon of factors. According to Shulman (1986), teaching involves a transformation of subject matter (content) into forms that are accessible to learners by the teacher. For example, although the content and consequently, goals for the course may already be pre-determined by curriculum developers in the syllabi or course outlines, the teacher who in turn selects teaching methods, transforms this in order to deliver it to the learners. The

craft knowledge of transforming content to a learnable form is referred to as Pedagogical Content Knowledge (PCK) (Shulman, 1986). In order to provide a full understanding of PCK, Rhemtula and Rollnick (2006) produced a model, which gives a picture of how PCK is arrived at and how it manifests itself (see figure 2). Although the model was tailored towards South African needs, it can be applied to other countries as well.

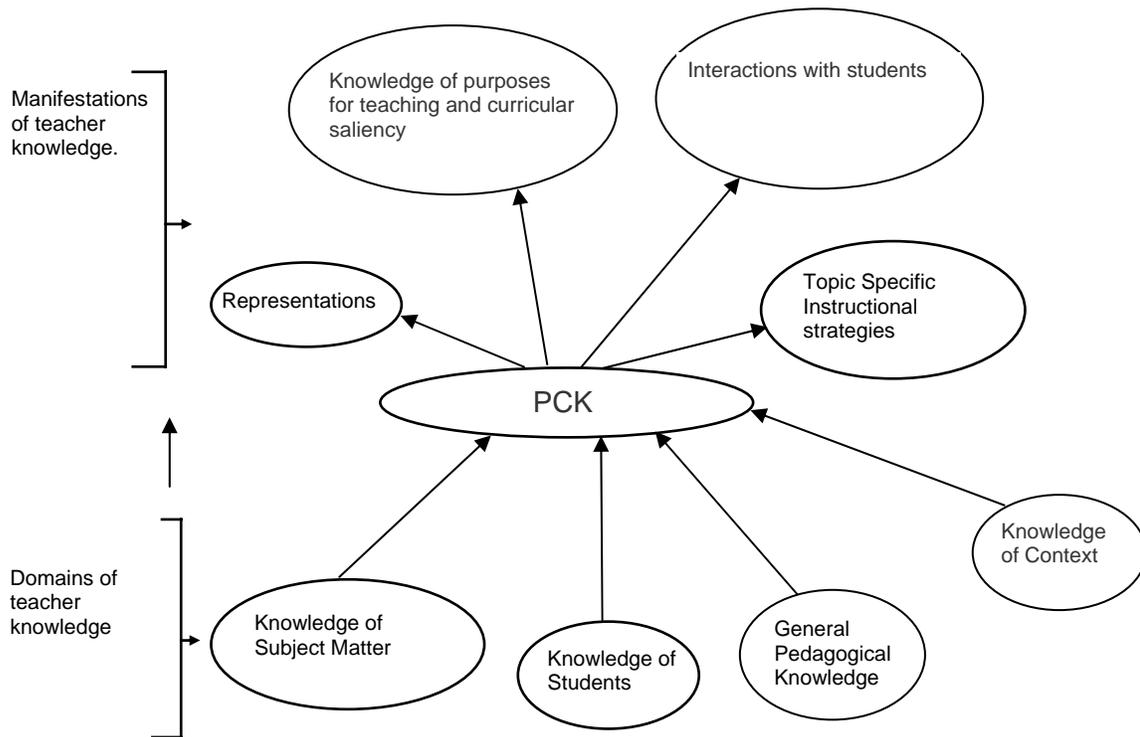


Figure 2: Model of PCK (taken from Rhemtula & Rollnick, 2006)

According to this model, a teacher makes use of various kinds of knowledge in order to come up with PCK including;

- Learners' prior knowledge and other characteristics
- Subject matter knowledge.
- General pedagogical knowledge
- Knowledge of context such as curricular materials, learning environment etc

These kinds of knowledge are referred to as domains of teacher knowledge. During the teaching and learning process, the model suggests that PCK manifests itself in various ways including, representations made by the teacher including metaphors and illustrations; curricula saliency (e.g. depth of coverage, what to leave out and what to teach); nature of interactions with students and topic specific instructional strategies. These are referred to as manifestations of PCK in the model.

The summary judgment from the model is that the teacher makes use of and consequently has a reasonable degree of control over most factors influencing the teaching and learning situation discussed earlier including learner background and other characteristics, content and consequently goals, general and subject specific teaching

methods and the general conditions and context. This is why she is regarded as a key leverage point in the teaching and learning situation. What this suggests is that adequate provision of appropriately trained teachers is of paramount importance if the development of human capacity in SMT for poverty reduction is to be achieved.

The demand for science and mathematics teachers

The demand for secondary SMT teachers in Malawi has always been high, and is probably increasing every year. The reasons for this are two fold. The first is that perhaps as a result of the commitment to SMT human capacity development as stipulated in the policy documents, science and mathematics are core subjects in the centrally controlled secondary school curriculum. The core science subjects include biology and physical science, the latter being a combination of physics and chemistry. Although there is evidence that some students drop these subjects, more especially physical science, by

Science and Technology, 2001). One area that has very few qualified teachers is that of SMT where human capacity for poverty reduction is needed the most. In the absence of subject-disaggregated data on number of qualified teachers currently in the schools, University graduation data could be used to illustrate the problem. To-date, the University of Malawi and other secondary teacher training institutions within the country train very few teachers in the natural sciences compared to the humanities. Table 1 for example shows the number of science education graduates from the two main universities in the country.

Table 1: Number of science education graduates by year and gender

Year/No. of graduates	2000	2001	2002	2003	2004	2005	2006
University of Malawi	44	76**	53	22	39**	63**	46
Mzuzu University	0*	0*	0*	46	19	34	~
Total	44	76	53	68	34	97	46

*Mzuzu University had not yet started

** Includes mature entry students

The Table shows that the number of graduating teachers is small, at least for the number of secondary schools in the country (612 schools). As a result, SMT is taught by unqualified teachers, a situation that has partly affected, and continues to do so, the quality of school science and mathematics education. This, in turn affects the number of students opting for SMT in the university, and other tertiary institutions, as will be discussed in the next section.

Opportunities and challenges of training adequate SMT teachers

Having analysed the demand for SMT teachers in the secondary school sub-sector in Malawi, the question that one could raise is why are the teacher training institutions not training sufficient numbers of these teachers? In trying to answer this question, one may start by looking at the existing opportunities for training the required number of SMT teachers.

As argued earlier, the University of Malawi is the oldest and main University in the country, housing the oldest and main faculty of education, which is responsible for training of secondary school teachers. Selection of students into the university, on Government scholarship, is based on available bed space. Each programme has got a fixed bed space so that it is difficult to go beyond it. However, since three years, the bed space for selection of education students has been increased to 50 percent of the intake at Chancellor College, one of the five constituent colleges of the University of Malawi, which houses the faculty of education. This translates into a maximum of about 200 bed spaces, but usually about 150 and sometimes even less, for education students. This policy has resulted into a subsequent reduction in bed spaces for other programmes including science, social science, humanities etc offered at this college. Despite the variation in numbers, the fact that education students take up half the number of spaces for Chancellor College could be taken as an opportunity to train the required SMT teachers. The most likely approach would be to allocate half of the available spaces or

more to students for science and mathematics education with the remaining number reserved for education humanities students.

In practice, and as can be seen from the graduation statistics in Table 2, few normal entry students graduate in science and mathematics education from the University of Malawi. The view in this article is that there are two challenges that negatively impact on student numbers in science and mathematics education. These challenges include the relatively few numbers of students opting for science and mathematics as they make choices for selection and, of the few students that are enrolled on this programme, some chose to major in the 'softer' sciences of H/Economics and geography not the natural sciences. These challenges will be discussed in detail in turn.

Student choices for University programmes

In the University of Malawi, just like in many other universities, students make choices for the kind of programmes that they would prefer to pursue when selected. The students are asked to make three choices: first choice, second choice and third choice. The various levels of choices are required because the university takes in very few students (approximately 1% of those that sit for the school leaving certificate examinations) due to space limitations as discussed earlier. In addition, each programme is allocated specific bed space so that once these are filled, no more students are taken in. As such, students who fail to make it into their first choice but still qualify for selection (are within the cut-off point) are selected for their second choice and later the third choice. It should be noted that in the event that some students meet the cut-off point but all their three choice programmes are full, they are redirected to any other programme, which is not yet filled, a practice that forces students into areas they may not be comfortable with.

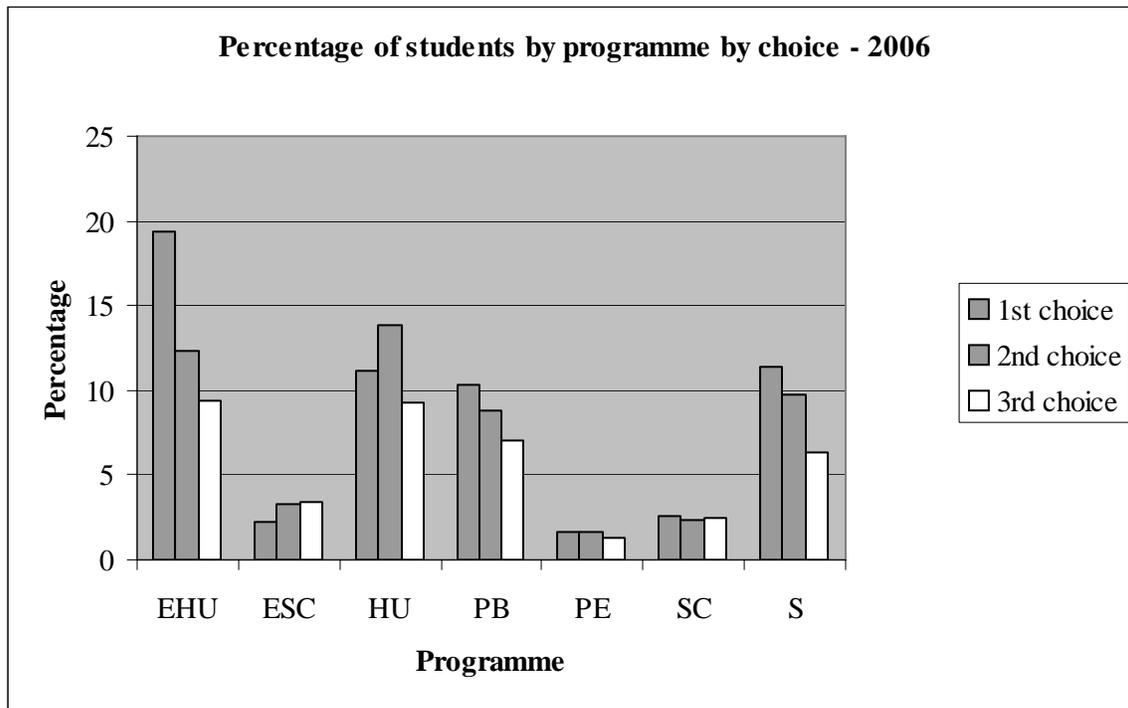
Analysis of statistics on student choices show that much as the country might require to train more SMT teachers, the reality is that very few students opt for education science and mathematics programme (ESC), as well as other science-related courses, in their choices. For the past five years for which there is data, statistics show that the majority of the students opt for humanities programmes including education humanities (EHU) and general humanities (HU) in all the three choices. Social Sciences, which lie in between natural sciences and humanities, usually comes second in terms of the choices and Business Studies comes third. Science programmes such as Education science (ESC), Bachelor of Science (SC), Engineering (PE), all come much lower in the choices. Table 2 for example shows the ranking on student choices for a few of the over twenty programmes offered by the University of Malawi for 2006.

Table 2 Student choice by rank for 2006

Rank	1 st choice	2 nd choice	3 rd Choice
1	Education Humanities (EHU)	Humanities (HU)	Journalism (JOU)
2	Social Sciences (SS)	Education Humanities (EHU)	Media for Development (MFD)
3	Humanities (HU)	Social sciences (SS)	Education Humanities (EHU)
4	Business Studies (PB)	Business Studies (PB)	Humanities (HU)
8		Education science (ESC)	Education science (ESC)
10	Bachelor of science (SC)		
11	Education Science (ESC)	Bachelor of science (SC)	Bachelor of science (SC)
13	Engineering (PE)		
15		Engineering (PE)	
20			Engineering (PE)

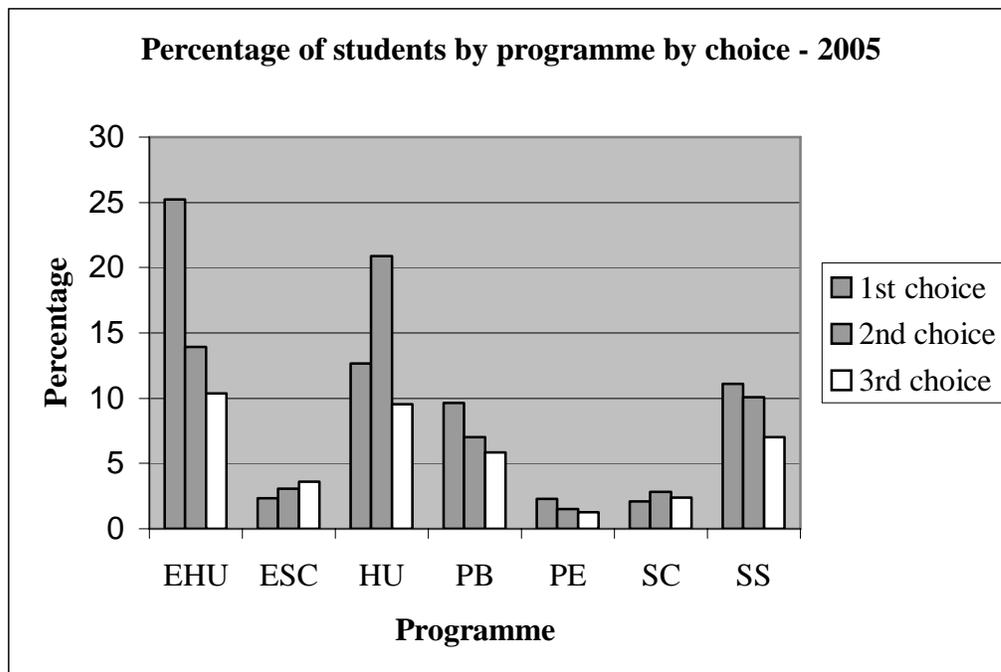
_____ Continuous ranking -----Ranking not continuous

Graph 1 illustrates how the choices appeared in terms of student numbers for the seven programmes (excluding Journalism and Media for Development which are not the interest in this article) in 2006.



Graph 1: Student choices 2006

For 2005, a similar trend is noticed and the same could be observed with student choices from earlier years. Graph 2 shows the picture for 2005.



Graph 2: student choices 2005

There are a number of factors that may contribute to the observed trends student choices, which are not the subjects of this article. However, what is clear is that even if the university were to increase the number of students enrolled in education science and mathematics (ESC) to increase the number of SMT teachers, this is limited by the low number of students opting for the programme. In addition, of the few students that opt for the programme, some do not meet the cut-off point for selection and are therefore left out. Instead, some students who meet the cut-off point but did not chose to study ESC are selected into the programme, a process commonly referred to as re-directing. For instance, the picture for re-directed students into ESC is worrying for the year 2006. During selection, fifty students were selected into the programme. Out of the fifty, only two had made ESC as their choice and this choice was third. The vast majority (48) did not chose ESC anywhere, but since they had met the selection cut-off point, but all the three programmes they were interested in were full, they were redirected into ESC. The students that had made ESC as their first or second choice did not meet the cut-off point.

The process of re-directing students has it own weaknesses. For one thing, the students may not be committed to a profession they did not chose to do, and therefore affecting their level of commitment towards studies. In addition, such students may not have a scientific orientation thereby leading to difficulties in undertaking some courses in the programme, which may consequently affect the quality of teachers trained.

Choice of majoring subject

The second challenge faced by the University teacher trainers is that of the few students enrolled for SCE, some opt to major in the 'softer' sciences of H/Economics and geography. Table 3 illustrates this for the past three years and projected look for 2007 based on current registration statistics. Although there is no pattern in terms of the number of students shunning away from the natural sciences and mathematics as their

major subject over the years, it is clear that there is a loss of a minimize of about sixteen percent of the students to H/Economics and Geography. The reasons for this trend are beyond this article. However, anecdotal evidence suggests that this is largely due to the relative difficulty of the natural sciences. In addition however, it would appear that there are better job prospects with the two subjects that there are with the natural sciences if the students are to quit their teaching job.

Table 3: Percentage number of students majoring in H/Economics and Geography

Year of study	Students majoring in		Total No. of ESC students
	H/Economics	Geography	
2007	10 (12%)	6 (7%)	85
2006	1 (2%)	10 (19%)	52
2005	3 (5%)	7 (11%)	65
2004	6 (15%)	5 (13%)	39

Policy recommendations

The analysis in this article suggests that there are problems in meeting strategies related to increasing SMT human capacity for poverty reduction in Malawi. This is because very few SMT teachers are trained leading to eroding of quality of secondary school SMT education and consequently, demand for tertiary SMT education. The University of Malawi faces a number of challenges some of which can be minimized by:

- Relaxing admission rules so that ESC students could be taken even below the cut-off point and therefore minimize re-directed students into the programme. Such students could be offered bridging courses depending on the core knowledge and skills that may be deemed lacking.
- Making the university SMT curricula more responsive to learners' and societal needs so as to make it less difficult and friendlier to the students. There is evidence that currently university curricula emphasises abstract concepts that have nothing to do with anything else (Nampota, 2005).
- Provision of more scholarships for ESC students and publicising these in the schools before students make their choices.

In addition, the University of Malawi could consider two other options:

- Offering a University Certificate in Education (UCE) course to students who graduated with a Bachelor of science (SC) most of whom have not found jobs.
- Training the unqualified teachers currently teaching science and mathematics subjects in the schools, most of whom possess a primary school teacher training certificate.

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