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Developing Research Skills in Mathematics, Science and Technology Educators in Southern Africa: The Role of a Professional Organisation

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Abstract

An established professional organisation for researchers in mathematics, science and technology education (MSTE) in southern Africa initiated a program, Skills for Development, aimed at developing research skills for novice MSTE researchers in Mozambique, Swaziland and Zambia. Through case studies for each of these countries this paper seeks to identify relationships between aspects in the contexts of implementing MSTE research, and the outcomes and impact of the skills training program. The data suggest that outcomes in terms of an increase in research capacity are limited in poor contexts where potential novice researchers give priority to income generating professional activities. They also suggest that even in better economic contexts, teachers may drop out, but are less likely to do so if they work in groups. In contexts where no research priorities are set by policy makers, the impact of the research seems to depend on the strength of the (informal) relationship between the Ministry of Education and the MSTE research community, and on the way the Ministry perceives its role in supporting research. The data provide examples of impacts the Skills for Development program has had on the school science curriculum, on a further degree training program, on the development of a national professional organisation, and on classroom interactions.

Background

This paper reports on part of a study of the effectiveness of a Skills For Development (SFD) project aimed at improving the research skills of mathematics, science and technology education (MSTE) researchers in eight countries in southern Africa. The project was structured as part of the skills development program of an existing regional professional organisation, i.e. the Southern African Association for Research in Mathematics, Science, and Technology Education (SAARMSTE). This paper specifically presents the experiences during the pilot period of the SFD project (2001-2004) in three countries: Mozambique, Swaziland and Zambia.

The professional organisation: SAARMSTE

The Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE), formed in 1992, is a professional forum for promoting research activities and disseminating research findings in the area of MSTE. Similar professional organisations for MSTE research exist for the USA and Europe. SAARMSTE draws its more than 200 members mainly from Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe. The constitution states the mission of the organisation as:

* providing a vehicle for capacity building in MSTE research skills for development;
* providing an opportunity for sharing research findings, thus building a regional professional network.

To achieve these ends, SAARMSTE holds annual conferences with refereed proceedings, publishes regular newsletters and a fully refereed internationally recognised academic journal, and in its early years, provided short courses and training workshops.

In the past, the development of research skills was mainly limited to South African colleagues due to restricted funding by local industrial sponsors and the (South African) National Research Foundation (NRF), and depended on how active the Research Development Officers (RDOs), appointed annually for areas within South Africa, were. The need for development of research capacity in countries outside South Africa was recognised by encouraging the formation of national professional organisations, called SAARMSTE Chapters, and by appointing onto the Executive Committee an additional RDO for the southern African region outside of South Africa. This RDO, in 2000, was an experienced science education researcher from Zimbabwe. In consultation with the SAARMSTE Executive, he conceptualised the SAARMSTE Skills For Development (SAARMSTE-SFD) project, confirmed concrete training needs, sought commitment within the region, and identified the British Department for International Development (DFID) as potential supporter and the University of York, UK, as the collaborating institution. In conceptualising the project he drew on the pioneering training experiences of Zimbabwean MSTE researchers.

The SAARMSTE-SFD project as intended

The SAARMSTE-SFD project aimed to assist in the development of MSTE in southern African countries through empowering local personnel with requisite skills to provide research-based evidence for decision-makers in education. Evidence-based decisions by policy-makers and practitioners are more likely to lead to realistic educational targets and considered curriculum changes, and thus avoid wastage on ineffective educational remedies. It is anticipated that improved MSTE, in turn, will result in more efficient use of resources and greater socio-economic development within the countries concerned, thus contributing directly to poverty reduction. The more immediate SFD project objectives included:

* building capacity in MSTE research by developing research skills through engagement in small-scale research projects;
* assisting policy makers and practitioners to make evidence-based decisions on MSTE;

* identifying characteristics of the MSTE environment facilitating or hindering research skills development.

During a project planning meeting in 2000, representatives from the MSTE research communities in Botswana, Lesotho, Malawi, Swaziland, Zimbabwe and Zambia identified two major needs. First, across the region, training was required in a variety of research skills. Support was needed for identifying research needs, planning manageable research projects, identifying research strategies suitable for the region, collecting valid data, analysing data reliably, making valid interpretations of findings, drawing practical implications, and reporting these findings. It was decided that skills training activities during the initial phase (2001-2004) would focus on fledgling MSTE research communities in three countries, Mozambique, Swaziland and Zambia, selected because of the diversity in their socio-economic circumstances, in the context of MSTE research, and the level of institutionalisation of the local professional organisations for MSTE research. Secondly, a need was identified for strengthening networking within the region and for celebrating and exploiting expertise already available. This second aspect is not covered in this paper.

For each calendar year SAARMSTE Chapters have submitted an annual Research Skills Training Plan for discussion and approval by a Steering Committee with membership from the SAARMSTE Executive and from MSTE communities in all countries involved. These annual training plans, generally included at least two national research skills training workshops per country, based on locally identified needs. Training was provided for all stages of research in order to plan and execute small-scale research projects identified by the participants, and was intended to culminate in a presentation at the SAARMSTE conferences as part of the dissemination of research findings.

In order to support the SFD activities, the project provided funds for these workshops. This allowed for travel and accommodation costs for participants; a very limited grant for research expenses per research project; a limited number of facilitators from within the country, the southern African region or from the University of York to participate in workshops; and contributed to the purchase of Chapter computer hardware.

The SAARMSTE-SFD project did not aim to provide joint Masters or PhD programs in MSTE such as currently offered by Norwegian universities (Oslo and Bergen) in collaboration with the University of the Western Cape in South Africa. However, this project, by involving novice researchers in structured research activities in their SAARMSTE Chapters, may provide the spawning ground for students entering formal further-degree training programs. This project reinforced the strengthening of MSTE research skills within major collaborations of other projects, for instance, those of the Belgian, Dutch and Swedish governments with the Harare Technikon, the University of Zimbabwe and the Curriculum Institute in Maputo respectively, and of DFID Higher Education Links with the Universities of Botswana, Namibia and Swaziland.

In addition to the development component, the SFD project also has a considerable research component. This paper draws on part of the research program underlying the SAARMSTE-SFD project.

Theoretical framework

A study of the factors influencing the effectiveness of continuous professional development of MSTE researchers through a professional organisation such as SAARMSTE needs to recognise that it is a non-governmental organisation (NGO), characterised by 'independence from government; a non-profit status and a voluntary decision-making structure' (Smith 1989, p.395). The relative weight of these three main characteristics already provides some possible indicators influencing the effectiveness of a professional NGO such as SAARMSTE. For instance: *How does the closeness, and the specific areas, of collaboration with government affect the effectiveness of research skills development? How are choices between consultancy research and action research aimed at improving own practice influencing the effectiveness of research skills development.* Comparing situations where NGOs have an advantage in delivery over governments in developing countries, Green and Matthias (1997) identify situations where the government is supportive of certain work but lacks needed knowledge and capacity, or cannot coordinate activities for whatever reason.

The project intervention consists of a structured sequence of workshops focusing on practicing different research skills required for progressive stages of a research project (see, for instance, Grayson and Mutimucuio, 2004). Typically, abilities are improved whilst trainees develop their own research proposal, instruments, analysis frameworks or research reports. In addition, novice researchers may be linked to more experienced peers as mentors or 'buddies' as described by Thijs and Van den Berg (2002). The approach to continuous professional development is thus a mixture of the induction methods propagated by Joyce and Showers (1996) and aspects of situated cognition as explained by Lemke (1997).

Aim of study

In this paper we focus on just two of the SFD project objectives: building capacity in maths, science and technology education (MSTE) by developing research skills, and identifying factors which facilitate or hinder the development of research skills. To achieve this we examine not only the development activities which took place, but also the research context in each country including the operation of the local SAARMSTE Chapter which facilitated the activities. In particular, the paper addresses the following research questions:

(i) How do the systemic features in the contexts of undertaking MSTE research in different countries facilitate or hinder MSTE research skills development?

(ii) How do these contextual features affect the impact of research findings by policy-makers and practitioners?

Research methods

The study utilizes a case study approach for the three countries, using a set of predetermined general descriptors for investigating (i) the context of MSTE research including

the organisational features of the SAARMSTE Chapters before the intervention and (ii) the nature of the research training activities in the different countries.

In order to depict the different contexts for MSTE research, data have been collected in each country through interviews with around 15 key participants, for instance, with personnel of the Ministry of Education (MoE), curriculum centres, examination councils and inspectorates/advisory service; pre- and in-service teacher educators; science education researchers; current and former chapter executive members and active and less active SAARMSTE members. For a full description of the SFD training activities, interviews have been conducted for each country with local and external training facilitators and five to eight workshop participants. The training programs, workshop materials, participants' research plans, instruments and conference papers were collected. In addition, questionnaires have been used to collect information on all participants' perceived training needs, their expectations of the SFD training activities, and views on the extent to which the experiences have met these needs. In some cases, the validity of the interviews was increased by the interviewer being familiar with the context (for instance when interviewing research officers in the MoE or examination councils), in other cases the validity of the interview data benefited from the use of an 'outsider' using telephone interviews (for instance when interviewing chapter executive members or workshop facilitators).

Interviews were transcribed *verbatim* and, where required, translated. Using a grounded theory approach (Glaser & Strauss 1967) for the analysis of each country case study, these scripts and other written documentation were read and re-read in order to identify issues for each of the pre-determined general descriptors of the MSTE context and for the nature of the intervention activities. A diversity of indicators for outcomes and impact were developed from the data. Triangulation of data from different data sources strengthens the trustworthiness of the inferences.

Findings: The project as implemented

The context

Local conditions in developing countries often differ significantly from those of more developed regions, and can have a marked impact on what happens in the countries. Data on demographics, economic measures, and technological infrastructure provide an important backdrop to assist in understanding local conditions and interpreting the research data. Table 1 provides a summary of some key indicators for Mozambique, Swaziland and Zambia regarding factors which may have impacted on the SFD initiatives in the three countries. For comparative purposes data have been included for South Africa (a more developed country in the region), and Japan and the UK (as highly developed countries).

Table 1 indicates that Mozambique and Zambia cover large areas and, as a result, have a very low population density, making travel for meetings a problem. In contrast, Swaziland is compact and has a relatively high population density. Economic indicators and the more developed communication network (judging by the density of telephones and personal

computers, and internet usage) suggest that Swaziland is economically more developed than either Mozambique or Zambia.

The contexts for engaging in MSTE research in each of the three countries at the beginning of the project implementation (the end of 2001) are summarised in Table 2. Five relevant aspects are included, i.e. the way the research agenda for MSTE is constructed; the funding opportunities of MSTE research; the existing in-country research training; the existing professional organisations and the internationally recognised research expertise in MSTE within each of the three countries. The data are compiled mainly from interviews with senior personnel in the Ministries of Education, the curriculum centres, inspectorates, examination councils, tertiary institutions, and pioneer MSTE researchers in the various countries.

It is pertinent to note that Minsitry of Education research agendas for MSTE, a critical area for educational improvement for the future of any developing country, do not seem to be high priority matters. While Swaziland has a research agenda, MSTE does not receive attention. In Mozambique and Zambia only the primary level seems to be targeted. In Zambia research is supported via a new teacher education program for primary teachers (ZATEC), which targets action research by teachers, emerging from their actual classroom experiences. Research foci at secondary level do receive some attention from the Ministry in Swaziland, but in Mozambique such research depends on areas of interest and expertise of academic staff involved in research at the universities. Over the last few years, the agenda for educational research has been influenced by demands of (international) agencies, often concerning the need for surveys of pre-intervention base-line data as part of international comparisons.

Little if any financial support for research is available in any of the three countries. Existing staff in Ministry curriculum centres may be used for evaluation reseach (as is the case in Swaziland and Zambia), whilst any comissioned research usually requires donor funding (for example, in Mozambique INDE received support for evaluative research from the Swedish Aid agency SIDA, and in Zambia a baseline study was commisioned by the Japanese Development Agency). Tertiary institutions generally have little or no funding for the research of the MSTE staff. In Zambia we were told that the university MSTE staff are considered to be “somehow part of the Ministry”, and are used to obtain information “when the need is felt for information to inform policy decisions”. In such cases the work is funded by the MoE, and it appears from interviews with the university staff that this is used to supplement their low salaries. *Ad hoc* research by teachers is also funded in this way, and can be used to release teachers to do such work. The Examination Council of Zambia has made little use of university staff for their research needs, although they feel this barrier “needs to be broken”.

Existing pathways for research skills training are mainly by indivudals registering for higher degrees, and often (even in countries which have their own Masters programs) the students register in South Africa or overseas. In Maputo another route is available, as research training in MSTE is provided for undergraduate and post-graduate students at both universities in the area. Opportunities for post-graduate MSTE programs are, however, now opening up in Mozambique and Zambia.

Table 1. Indicators for selected developed and developing countries

	Mozambique	Swaziland	Zambia	S. Africa	Japan	UK
Land area (km^2)	801600	17360	752699	1200000	377800	242900
Population demographics						
2003 population (million)	18.8	1.1	10.4	45.3	127.2	59.3
People per km^2	23.5	63.4	13.8	37.8	337	244
Annual population growth rate (2003)	1.9%	1.6%	1.5%	- 0.1%	0%	0.1%
Life expectancy (years)	41 (2002)	44 (2002)	37	47	82	78
Percentage of population urbanised	35%	26%	40%	58%	79%	90%
Economic indicators						
GNI (per capita income) US$	210	1350	380	2600	34510	25250
% of population earning < 1 US$ a day	38%	2%	64%	-	-	-
Annual rate of inflation	27%	12%	45%	9%	0.1%	3%
% government expenditure	5%	8%	13%	-	2%	15%
(*health, education, defence*)	10%	20%	14%	-	6%	4%
	35%	8%	4%	-	4%	7%
Educational indicators						
Total adult literacy rate	47% (2002)	81%	80%	86%	-	-
Net primary school enrolment	54%	93%	89%	89%	100%	99%
Technology and infrastructure						
Telephones per 1000 people	19 (2002)	95	21	410	1195	1431
Personal computers per 1000 people	4.5 (2002)	24.2	7.5	72.6	382	405.7
Internet users	10,000 (2001)	20,000 (2002)	52,420 (2002)	3.1 mill	57.2 mill	25 mill
1 user per X people	1880	55	198	15	2.2	2.4

Source: 2003 data from Unicef or Worldbank, unless otherwise indicated.

Table 2. Summary of the context of MSTE research in Mozambique, Swaziland and Zambia

Aspect considered	Mozambique	Swaziland	Zambia
Setting of the MSTE research agenda	* No research priorities are set by the MoE. The curriculum development centre (INDE) has a coherent program for evaluating curriculum renewal, especially at primary level. * Priorities are set according to areas of interest of staff at tertiary institutions, mostly for research at secondary level teacher education. * Some priorities come from donor-supported government projects e.g. for base-line studies	* Education research priorities are set by an Advisory Committee to the MoE, but not specifically for MSTE. The curriculum development centre has an ad hoc program for evaluating curriculum renewal, especially at primary level. MoE subject panels provide some priorities for secondary curriculum research. * Few priorities are set by donor-supported government projects.	* Research priorities have been identified by the MoE, and research is done by their own staff or academics from universities, often as PhDs. * The Research and Test Development Department of the Exams Council (ECZ) conducts assessment-related research. * Some priorities result from donor-supported government projects, especially for baseline studies and intervention evaluations.
Funding of MSTE research	* The MoE has established staff positions in its Department of Statistics, but until recently these data are hardly used for policy formulation. The MoE provides support by releasing teachers for research activities, and covers expenses. * INDE has designated staff for evaluation. * Tertiary institutions have little or no funds allocated for research by staff. * Some commissioned MSTE research is funded as part of donor-supported projects.	* The MoE has established staff positions in its Department of Statistics, but these data are hardly used for policy formulation. The MoE provides support by releasing teachers for research activities. * The Curriculum Centre has staff for evaluation. * Staff at the university can bid for small amounts of research funding. * Commissioned MSTE research is minimal.	* Every MoE section and the Exams Council has a budget for research, used “when the need is felt” for information to inform policy decisions. * The MoE funds a Data-base Unit which replaced the Educational Statistics Department. * Contributions made to the maths and science teacher associations, may be spent on research. * A new teacher education program for primary teachers (ZATEC) includes action research. The MoE releases *ad hoc* funds for such teachers. * Tertiary institutions have no funds for research by staff, other than donor-funds. * Most MSTE research is through donor-supported projects.
In-country training for MSTE research	* Two universities provide Masters programs in M&S Education with about 12 students. * PhD candidates study in South Africa, Australia or Germany, many part-time.	* The university has an MEd program, but few if any students in MSTE. * Higher-degree candidates study in South Africa, frequently on a part-time basis.	* The university has an MEd program, but no specialism in MSTE. * Further degree candidates study in the USA, South Africa or Australia, often full-time.
Professional organisation for MSTE research	* A young SAARMSTE Chapter exists with its focus on dissemination and reviewing on-going research, not so much training. * A major impetus was provided by organising the SAARMSTE conference in Maputo, 2001.	* An informal group of MSTE researchers exists, driven by keen individuals. * The Swaziland Education Research Association thrives, but without a focus on MSTE.	* No organisation of MSTE researchers exists. * A small number of MSTE researchers are active as individuals.
Internationally recognised expertise in MSTE	* Ethno-mathematics and ethno-science. * Gender and MSTE. * Strategies to address science misconceptions.	* Context-based learning of science, including the use of indigenous technology. * Continuity/progression in the science	* HIV/AIDS education across the curriculum, including in MSTE. * Gender and MSTE.

SAARMSTE plays a significant research-related role in both Mozamque and Swaziland, fuelled by the efforts of keen local researcher members. For example, in Mozambique, even before the SFD projeect, they held regular seminars, had visitors from abroad, published a small informal journal of the seminars, and organised the 2001 SAARMSTE conference. In Zambia an inertia prevails, possibly influenced by the lack of a research ethos in the country, which has made it difficult to sustain an interest in research activities. The pioneers in Zambia confirmed that workshops were first held only after the SFD project started.

In spite of the challenges posed to MSTE reseachers in these developing countries, each country has areas of expertise recognized by the international MSTE community. In each case it can be seen that the local contexts have facilitated research in the particular areas of expertise.

What was done

The activities for the development of research skills followed a similar pattern in the three countries for three annual cohorts in 2002-2004, although there were several major variations between countries and subsequent cohorts. As a guide, the activities for the research skills training in Swaziland are illustrated in Table 3.

Table 3. Sequence of SFD training activities in Swaziland

Stage	Type of activity	Timing	Intended outcome
1	3-day Workshop 1	February	Definition of research area and research questions; familiarity with a variety of research designs and quality instruments; constitution of research group; agreement on research design and program; draft of data collection instrument; where required, practice with data collection technique.
2	Fieldwork with mentor support	March - May	Piloted data collection instrument and strategy; set of pilot data; identification of relevant literature.
3	3-day workshop 2	May	Refined data collection instrument and strategy; familiarity with different analysis methods and instruments, and literature review methods; awareness of issues of validity, reliability, trustworthiness, research ethics; selection of appropriate data analysis method; development of draft analysis scheme based on pilot data.
4	Fieldwork with mentor support	May - August	Selecting a theoretical framework from the literature; substantive data collected; analysis of data.
5	3-day workshop 3	August	Skills in writing abstracts, conference paper, and conference presentation; draft of abstract for submission to SAARMSTE conference; structure of conference paper.
6	Writing	August - October	Conference paper; presentation materials.
7	1-day practice presentation	November	Peer feedback on paper; peer feedback on presentation strategy and content; confidence! Dissemination of findings for local audience.
8	SAARMSTE Conference	January	Dissemination of research findings for international audience.

The 8-step cycle of SFD activities in Swaziland as presented in Table 3 is the most complex combination used in any of the three countries. Even with this intensive support, several participants and facilitators felt that lack of time for practicing specific skills such as literature searching, quantitative data analysis and writing a research paper was a problem. Mentoring by the local facilitator during field work was highly appreciated, providing general encouragement and a reminder of the task at hand, but was not seen as a way to replace focussed training for any of the skills mentioned above.

In Mozambique, only two workshops were held annually. The second, usually towards the end of June, had a heavy program combining the intended outcomes of steps 3 and 5 of Table 3. Again, several participants commented that they would have liked more frequent episodes of intensive skills training. During the first two years (2002 and 2003) only one workshop per year was organized in Zambia due to lack of interest. This resulted in cohorts 1 and 2 merging, and the long lapse between sessions resulted in loss of momentum of the earlier training program.

Outcomes and impact

The data from participants, training facilitators, SAARMSTE chapter executive members and established MSTE researchers provided ample insight in the effect of the SFD training program. Such effects may be grouped as outcomes, in terms of the change in research capability, and as impact, in terms of the influence the research training program and the research findings have had on various components of the education system. Outcome indicators include the number of MSTE researchers involved in the training program, the professional backgrounds from which these trainees are drawn (and hence constituencies affected) and the research areas to which novice researchers have contributed. An external quality indicator is the number of papers accepted by anonymous reviewers for conference presentation, and thus the number of studies incorporated in the conference proceedings. The different outcomes are summarised in Table 4.

Indicators for the impact of the SFD training program are taken to be any changes, based on the SFD activities, in the school curriculum, training programs, classroom interactions, or the nature and status of professional organisations like the national SAARMSTE Chapter. The summary for the impact of the SFD research skills training is provided in Table 5.

Because some researchers stayed on for more than a year it was difficult to say how many individual researchers participated (as opposed to how many people attended the workshops). Table 4 shows that the estimated number of participants in Mozambique (in Maputo and Beira), Swaziland and Zambia totalled 88, 57 and 24 respectively. Swaziland limited numbers based on available funding, while Mozambique deliberately opted for providing training for as many participants as possible. The number of Zambian participants is low since only one workshop was organised in the first two years, and the second workshop was therefore a continuation for the same cohort that attended the first workshop.

Not all participants completed a meaningful research project even if they did attend all

Table 4. Outcomes of SFD research skills training

Outcomes	Mozambique	Swaziland	Zambia
Estimated number of **new** MSTE researchers involved each year (2002/03/04)	88 (27, 20+13, 18+10) [Maputo and Beira cohorts for 2003 and 2004]	57(25,15,17)	24 (12, 4, 8)
Estimated breakdown of professional background of participants	45 Teachers 14 Univ/College staff 27 Post-grad students 2 MoE staff	28 Teachers 6 University staff 12 College staff 4 Curriculum Centre staff 5 MoE staff (inspectorate) 2 NGO staff	3 Teachers 3 Univ staff 13 College staff 1 Curriculum Centre staff 1 Exams Council staff 3 NGO staff
Major research areas	* The use of traditional technology in MST teaching * Effective labwork with limited resources * The use of ICT in understanding MSTE * Misconceptions and teaching strategies for specific difficult topics in MSTE * Using Maths for developing thinking skills	* The use of traditional technology in MST teaching * The effectiveness of context-based assessment * Students views on HIV risk behaviour * Continuous assessment in Maths * Misconceptions and teaching strategies for specific difficult topics in MSTE	* The use of traditional technology in MST teaching * Girls' achievement in MSTE * Maths performance of distance learners * Reasons for maths and science subject options * Teachers' views on implementing learner-centred education
Number of SAARMSTE papers presented* (2002, 2003, 2004)	21 (4, 12, 5)	14 (3, 5, 6)	4 (1, 1, 2)

* Note: these were not necessarily presented by participants from the workshops.

workshops for their cohort. The Swazi Chapter reports that 35 participants (just over 60%) have done a research project. The corresponding percentage in Zambia is very low, as a coherent training program only became viable with the third cohort.

The proportion of teachers amongst participants in Mozambique is high. In contrast to Swaziland and Zambia, where participants were recruited through personal contacts, teachers in Mozambique were identified with the help of the MoE. Provincial education directors were asked to suggest to school principals that they identify teachers who would be "committed to doing research as one of the ways to help understand school dynamics and solve a variety of school related problems" (Grayson & Mutimucuio 2004). The interviews revealed that this strategy had been very effective because employers knew what their teachers were involved in, and staff felt more committed.

Table 4 also shows that the major areas of research had a common element in the interest in the use of traditional or everyday technology for schools teaching MST. Apart from this, interests were diverse, with a focus on gender and the implementation of learner-centred education in Zambia; emphasis on the effectiveness of teaching strategies, including ICT, for understanding difficult topics in Mozambique; and a focus on context-based teaching and assessment in Swaziland.

The number of conference papers presented by all Mozambican, Swazi and Zambian

Table 5. Impact of SFD research skills training

Impact on:	Mozambique	Swaziland	Zambia
MSTE Policy making		* development of very close collaboration between MoE and MSTE research community; * curriculum change in secondary school science based on research evidence; * contribution to debate about the effectiveness of assessment by coursework in primary teaching; * adaptation of interventions on HIV/AIDS education by NGOs.	-
MSTE practice	* changes in classroom practice for teaching difficult concepts and the use of ICT.	* changes in classroom practice in teaching difficult concepts and the use of questions; * textbook writing by collaborative research group; * research and development contracts by outside funders; * adaptation of interventions on HIV/AIDS education by NGOs; * in-service program for strategies for teaching primary school maths based on research.	* (expected) inclusion of effective learner-centred strategies for MST teacher education.
MSTE research training	* minor changes in research project supervision strategies at the universities; * collaborative links between MSTE research groups at UEM and UNISA; * 8 participants enrol for post-graduate degrees in Mozambique and (few) in South Africa.	* minor changes in research project supervision strategies at the university; * 2 participants enrol for post-graduate degrees in South Africa.	* construction and implementation of MEd (maths & science education) at UNZA; * 12 participants enrol for post-graduate degrees in Zambia and South Africa; * co-ordinated professional development of MSTE tutors from teacher education colleges as part of a Belgium-sponsored project; * collaborative links between MSTE research groups at UNZA and UKZN.
SAARMSTE Chapter	* Chapter has viable size of membership; * Chapter has secure (basic) funding through fees; * Chapter has consolidated management structure; * Network and workshop exchanges with groups in Gauteng and Limpopo (SA) and Zimbabwe.	* Chapter has viable size of membership; * Chapter has secure (basic) funding through fees; * Chapter has established management structure.	* Chapter is still an informal grouping identified with university department of MSTE.

researchers from 2002 to 2004 totalled 21, 14 and 4 respectively. However, not all of these can be attributed to the SFD activities. For instance, only nine of the 21 Mozambican papers are reportedly from novice researchers. The distinction between novice and experienced Swazi presenters is less relevant, since Swazi papers were normally presented by research groups, often combining experienced and novice researchers, but novice Swazi researchers contributed to at least 11 presentations. All four Zambian papers were presented by experienced researchers, all but one by the same author. It is notable that so far none of the studies has been published in refereed journals, although Swazi participants report that two papers are being prepared for journal submission.

Not unexpectedly, Table 5 shows that impact of the intervention has been uneven. In Zambia the impact is mainly limited to the area of MSTE research training, i.e. the initiation of a Masters program at UNZA during the last year of the project. A large number (but not all) of the participants in the project training scheme thus enrolled for a further degree, a phenomenon also observed in Mozambique and, to a lesser extent, in Swaziland.

The main impact on policy making has been in Swaziland, where a close collaboration with the MoE culminated in major evidence-informed changes incorporating context-based learning approaches in the junior secondary science curriculum. The commissioning of several researchers for the development, piloting and evaluation of a school textbook by a local publisher represents impact on practice. Other spin-offs were some donor-funded research and development contracts in research areas developed during the project. In contrast, similar contracts for MSTE researchers in Zambia (Haambokoma *et al.* 2002) were awarded unconnected to involvement in the project. Some teaching strategies promoted by the Curriculum Centre in Zambia changed, and several interventions of NGOs active in the area of HIV/AIDS education were adjusted on the basis of a project's research findings. The impact on practice also includes non-systemic changes in classroom strategies of individuals involved in research (in Mozambique and Swaziland).

Institution building with regard to the local SAARMSTE chapters was achieved for both Mozambique and Swaziland. In both countries the professional organisation became a legal and financial entity, with an agreed constitution and elected executives, and a sizeable membership providing a critical mass of research-active people In both cases, SAARMSTE membership fees are being collected with a fixed percentage allocated to the local Chapters, thus providing a steady source of income. In contrast, the Zambian chapter still functions as a small informal group of like-minded individuals.

Discussion

The data provide several links between the context of MSTE research in the various countries and the effectiveness of the research skills training and its wider impact. We claim no generalizability of any of the findings as the data are drawn from case studies from only three countries, and changes due to influences other than the intervention have not been extensively explored. Taking account of these caveats, the study identifies a number of

issues.

The country context related to the outcomes of the research skills training

The uptake of the opportunity for professional development seems to be affected by the socio-economic context within which potential participants attempt to survive. In Zambia, with its relatively low per capita income and high inflation rate, the lack of uptake and the subsequent abortion of the first two training cohorts were related to the expectation, on the part of teachers in particular, of an attendance allowance to supplement their pay. The SFD project did not provide such allowances and only reimbursed actual expenses of travel, accommodation and meals. Haambokoma *et al.* (2002), in another Zambian study, also identified this expectation of attendance allowances. Several staff members in tertiary institutions reportedly also use economic arguments for prioritising remunerated development (and research) work commissioned by NGOs. In difficult economic circumstances the SFD model of research skills training seems unable to recruit participants, not surprisingly as potential participants tend to focus on the first category (physiological needs) in Maslow's (1987) hierarchy of personal needs. The research study by Haambokoma *et al.* (2002) may serve as an example of an alternative way of research skills development, even in tight economic circumstances. The study reconciled the *use* of existing local expertise with *building* of research skills capacity in the tradition of situated cognition (Lemke 1997), in that the study was executed by a large team with some experienced and many novice researchers.

In less depressing economic regimes the different motivations for participants affected the staying power rather than recruitment. In Mozambique and Swaziland several intrinsic and extrinsic motivators can be distinguished. Purely intrinsic motivations such as 'I'm interested in being a good researcher' or 'I feel satisfied when I can solve a problem' were rarely mentioned. Applied intrinsic motivators such as 'I have a problem in my work I want to solve' occurred more frequently (particularly for teachers and teacher educators). This motivation appeared to be related to drop-out: facing difficulties with collecting or analysing data some novice researchers decided to cease their involvement and rely on their own 'craft knowledge' (Hiebert *et al.* 2002; Leinhardt 1990) rather than research-based knowledge. It seemed that fewer drop-outs occurred amongst participants with a similar motivation, but working in research groups, a practice which was encouraged in Swaziland.

A higher persistence with the research skills training was often associated with extrinsic motivations. Examples of extrinsic motivations include the need to show research activity for promotion (mainly for staff at universities), research being part of a job description (for staff of the curriculum centres, examination councils and universities, less so for staff at education colleges) or intended further degree studies (for several teachers, tertiary institution staff and further degree students). In all three countries, informants suggested that SFD research experiences strengthened some participants' resolve to seek entry into higher-degree programs. In Mozambique, degree students took advantage of the training program as supplementary training input. In Zambia registering participants for a degree was used as a strategy to motivate novice researchers and ensure their ongoing interest and commitment.

SFD activities were made compulsory for students enrolled in a newly established part-time MEd program. It was hoped that this commitment would result in increased retention and guaranteed continuity of the SFD activities.

Equitable access to professional development was identified as an issue in two ways. Firstly, in Mozambique and Zambia geographical distance increased participation costs in terms of both money and time, resulting in lower attendance by participants from outlying provinces. In turn, these participants were more isolated and thus more likely to drop-out. From the second cohort onwards, Mozambique decided to operate from two centres, Beira and Maputo, meeting political sensitivities against centring provision in the capital only. Whereas a system of personal mentoring between workshops was feasible in Swaziland with short distances and reasonable communication, such support was much more difficult in Mozambique, and one visit a year to outlying districts had to suffice to follow-up on projects and mentor the researchers. The second, very different, issue of access arose in Swaziland. Concern about the balance of the research skills training across the different subject disciplines resulted in a conscious rotation of expert facilitators who had different specialisms, and a special session for neglected technology and technical subject education researchers was organized.

Country context related to the impact of the research skills training

Policymakers from the MoE in each of the countries do not provide a formal list of research priorities for MSTE. Only in Swaziland, the National Research Council uses a set of very general research priority areas, mainly to provide a framework for decisions on externally funded research. In cases of such lack of formal direction, the impact of MSTE research seems to be related to the strength of the informal relationship between the MoE and the MSTE community through joint involvement in, for instance, maths and science subject panels, teacher associations and examination setting and marking. Strong relationships, as are reported for all three countries, will create opportunities to debate, agree and communicate research priorities on the basis of development initiatives under discussion.

The perception of Ministries of their role in this relationship is crucially linked to the impact of the SFD project. For example, in Swaziland the MoE agreed informally on research priorities with the MSTE community, directly related to curriculum change at junior secondary level, and thus stimulated the integration of research outcomes directly into curriculum decisions, the production of exemplar teaching materials and of standard learning materials. Similarly, active encouragement is provided for an evidence-based change in teaching strategies in primary mathematics. The strong relationship between the MoE and the MSTE community resulted in financial support by the MoE. However, since the MoE has decentralised research to the curriculum development centre and has few research priorities in other areas, the potential benefits from the close relationship between MoE and the MSTE community have been limited, emerging mainly as an increase in further degree uptake and changes in classroom activities of individual researchers. In Zambia, several voices in the MoE indicate that any research needs to be closely related to activities within the Ministry's

departments and research is often done by MoE staff rather than the larger MSTE community (although university staff may be involved 'for their expertise' according to one MoE interview).

The fact that major changes took place in the organisational structure of SAARMSTE, with a new and clear financial relationship between mother body and national chapters, has had a major impact on the financial viability of the chapters. These changes were strongly encouraged by the fact that a prominent member of the Swaziland Chapter was Chair of the organisation during 2002, and a member of the Mozambican Chapter holds the Chair during 2004/5.

Conclusions

The study shows that a training intervention under the aegis of an established professional association aimed at an increase in the skills of mathematics, science and technology educators can have positive effects. The outcomes and impact may be further optimized by taking into account the educational contexts of the interventions. The study gives pointers for sustainability and thus suggests benefits for MSTE communities in other countries in the southern African region.

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