

University-school partnerships for social justice in mathematics and science education: the case of the SMILES project at IMSTUS

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My purpose in this paper is to situate a university-school mathematics and science education partnership within a social justice perspective in education. The focus of the systemic intervention endeavour was school-based teacher professional development in which university-based facilitators embarked on class visits with the aim of identifying teacher needs, co-teaching and offering professional support over a three-year period. This was in contrast to evaluation (inspection visits) often undertaken by the subject advisors under the auspices of the Department of Education which, for historical reasons, tend to be viewed with suspicion by teachers and teacher unions. Five historically disadvantaged secondary schools and their 10 feeder primary schools were involved in this study with a view to providing equal opportunities to learners from marginalized communities in the Cape Winelands district of the Western Cape. Initial results suggest that an intervention programme that is responsive to local needs can go a long way in bringing about collaborative teacher professional development that leads to reflective practice in professional learning communities and can add value to the quality of student achievement in the gateway subjects of mathematics and science.

Keywords: disadvantaged schools; learning communities; mathematics and science education; reflective practitioner; SMILES; social justice; teacher professional development; university-school partnerships

Introduction

South Africa has a dearth of students matriculating with maths and science pass rates that qualify them for further study in Science, Engineering and Technology (SET) careers. The mathematics pass rate for the 2010 cohort improved only marginally (by 1.4 percentage points to 29%) while the physical science pass rate improved significantly (by 11 percentage points to 30%) over the 2009 results (Mail & Guardian, 2011). This has serious opportunity costs and consequences for South Africa in the knowledge economy — locally and globally.

When school academic achievement is further disaggregated and analysed by quintile, underprivileged schools in quintiles 1–3 perform worse than well-resourced schools in quintiles 4 and 5. Recent findings by the Centre for Development and Enterprise (CDE) suggest that South Africa relies on just more than 400 top schools for half its mathematics passes at the 50 per cent level and about 350 schools for half its science passes at the 50 per cent level out of a total of 5,903 schools nationally (CDE, 2010). This calls for all stakeholders to help disadvantaged schools turn around.

It is in view of the persistent national crisis in mathematics and science education that the University of Stellenbosch, in keeping with the community interaction dimension of its

mission, initiated the Science and Mathematics Initiative for Learners and Educators (SMILES) schools partnership project in 2009. Guided by a conviction that no education system can exceed the quality of its teachers (Karpati, 2009), the intervention took the form of a school-based teacher professional development in five historically disadvantaged high schools, in the Cape Winelands District of the Western Cape, and their 10 feeder primary schools. The focus on redressing inequities of the past enabled the programme to attract funding from the Netherlands government for a three-year period (2009–2011). We are committed to a social justice perspective that recognizes that all learners are equally entitled to good teachers, irrespective of socio-economic disadvantage, race, gender or creed.

Theorising social justice in mathematics and science education

Teacher professional development as a potential tool for bringing about social justice Gindin (2002) defines a socially just society as one that fosters and encourages the full and mutual development of all the capacities of all members of society. This definition resonates with the principles underpinning curriculum transformation and development in South Africa as enshrined in the principal aims of the Constitution, Act No. 108 of 1996. These aims include healing the divisions of the past, establishing a society based on democratic values, social justice and fundamental human rights, improving the quality of life of all citizens and freeing the potential of each person. In other words, a socially just society affords all citizens equal opportunities irrespective of social class. This ideal is, however, not always the case even in education. Instead, the link between social class and educational attainment has become a key concern for educators, researchers and policymakers worldwide in that schooling has been found to be culpable in exacerbating social immobility and reinforcing current social stratification and social exclusion of marginalized groups (Gates & Jorgensen, 2009). It is argued that what is needed is to give the most disadvantaged a chair to stand on, and that calls for deliberate affirmative action and practices. Teacher professional development for social justice should thus invariably focus both on equity and a deeper understanding of the interconnections of power, privilege, difference, oppression and justice (Bose, 2005:78) — domestically and internationally.

Education as a social process is therefore inextricably linked to social justice discourse. Accordingly, a socially just mathematics and science education has an indissoluble ‘responsibility to develop and improve each and every learner, and needs to be sensitive to the varying needs and circumstances of all’ (Ernest, 2007a). Mathematics and science education form a core part of critical citizenship empowerment. To this extent we share Gates and Jorgensen’s (2009) view that the fundamentals of a socially just mathematics (and science) education must encompass access to the curriculum, resources, good teachers, and favourable conditions for learning. Mathematics and science teaching have a significant role in positioning pupils for success or failure as learners and citizens. Mathematics, in particular, has long been viewed as a gatekeeper and critical filter by which educators serve to perpetuate that status through objective structuring practices of allocating forms of capital such as grades, scores and awards that channel privileged learners into higher streams of mathematics learning (Bourdieu, 1983; Ernest, 2007a; Nolan, 2009). This objectification process is accompanied by more subtle and coercive subjective structuring practices which learners internalise as if they were inherent within the individual as inborn ability (Bourdieu, 1977). In this way the less privileged lower stream learners internalise their poor performance in mathematics tests and come to speak of themselves as failures (Zevenbergen, 2003). They develop low expectations of themselves,

even expect to have poor teachers as a self-fulfilling social (racial, ethnic, socio-economic) class misfortune or innate intellectual deficiency.

A social justice perspective on mathematics and science teacher education should, among other things, question streaming or tracking in mathematics and science (a widespread and almost universal practice) for working against the interests of many learners (Gates & Jorgensen, 2009). Sadly, such socially unjust practices are not always imposed on teachers but are voluntarily prosecuted and believed by them to be essential and biologically natural. The education system's measurement of school functionality in terms of percentage passes in mathematics (and science), as opposed to the quality of educational provisioning, complicates rather than simplify matters. It has created tensions and resulted in many mathematics (and science) learners being actively discouraged or persuaded from pursuing (pure) mathematics and (physical) sciences. This form of assisted academic suicide is undertaken to shore up pass rates, spruce up the school image, please authorities and exonerate policymakers and resource allocators. Mathematics, as an example, is then effectively window-dressed and portrayed as a subject not meant for the faint hearted: a subject constituted as the activity of following procedural rituals, with such rote procedures being regarded as ahistorical, unalterable norms, without a specifiable source, but fixed and self-evident, pre-defined (and even undefined), non-negotiable axioms and terms to be delivered, deposited, banked or implanted into the head of the learner (Cobb, Wood, Yackel & Mc Neal, 1992; Freire, 1972; Noss & Dowling, 1990; Povey, 2002). The subject matter is further rendered epistemologically less accessible by both educators and textbook authors through the omission of so called 'obvious' steps in the memoranda and/or entire 'working' or 'proof' in answer books. This more-difficult-to-comprehend proof is often elevated, above calculation and problem solving, to be the ultimate epitome of value-free mathematical knowledge and practice (Ernest, 2007b). Many learners who cannot see what is 'obvious' to the educator and the textbook author are condemned to reinforce a 'one-man-for-himself-and-only-God-for-us-all' attitude and a belief that mathematics is not meant for them but for the gifted. To further deny even half a chance to marginalized learners in historically disadvantaged schools, tests are conducted under tense 'speed and accuracy' conditions, and are evocatively encrypted in the language, culture and register of the dominant classes. The net result equals post traumatic stress disorders.

Such a mystification of mathematical (and scientific) knowledge is predicated on the transmission model of traditional teaching and leads to a form of symbolic and cultural violence (Bourdieu, 1979; Freire, 1972) in which the processes of domination are made possible through the shared doxa of the dominant and dominated where both parties approve and reward (unjust) practices. The joint acceptance that mathematics represents objectivity and impartiality, as an instance, leads to the false or mistaken belief that those who are successful do so as an apolitical, neutral and class independent act of their inherent worth and genetic endowment. Such a transmission model of teaching enables the dominant to retain their position of power while the dominated remain ignorant of their oppression. The oppressed even feel relieved that they have been spared the extraneous demands of the mathematics and science classrooms and thus take comfort in belonging to a 'self-excluded majority'. Very little, if any, attention is paid to the factors underpinning high quality pass rates in well-resourced schools (upper quintiles 4 and 5 schools in the South African context).

By contrast a socially just curriculum involves helping learners become more aware that whoever is considered knowledgeable and whoever is not mirrors the social positions and power of the knower (Povey, 2002). A mathematics and science education for social justice

should therefore unambiguously start with a teacher education endeavour capable of producing learners who can think critically, synthesize and transform, experiment and create (Gipps, 1993:40). That is, by providing a flexible mathematics and science education curriculum driven by active cooperative forms of situated learning, opportunities are availed for learners to experience the processes by which, for instance, mathematics is created, learned, and communicated through a context-bound and value-laden 'backstage' of trial-and-error that precedes the seemingly value-free 'frontage' of perfection that mathematics is often adorned with. This leads to a consideration of the characteristics of successful school-based teacher professional development initiatives in the context of a university-school partnership.

Conceptual framework for teacher professional development

Current research on teacher professional development, although diverse, points to the quest to address sustainable education system reform through teacher change to improve the quality of teaching and by extension lead to improved student achievement (Kennedy, 2005; Pop *et al.*, 2010; Towndrow, Tan, Yung & Cohen, 2010). An ongoing objective of most professional development programmes is accordingly to provide experiences that create change in classrooms and support reform-oriented teaching (Pop, Dixon & Grove, 2010). This implies that teacher development or the professional growth of teachers must fundamentally be concerned with our ways of thinking about effective teaching (Ling, 2003:11). Several models have been developed in this regard. There would seem to be two broad and largely opposing approaches relating to teacher professional development that could be adopted: a short-term, training-based agenda usually conducted offsite by an external agent, or the adoption of a more continuous, situated and learning-based approach (Towndrow *et al.*, 2010). Curriculum innovation is traditionally passed onto teachers through in-service professional development sessions (Kelly & McDiarmid, 2002) and appears to be predominantly done through efficiency driven short courses and workshops. This one-size-fits-all approach, however, has been shown to have limited effectiveness because of the strong central control and limited room for teachers' voices leading to inadequate professional appreciation. Teachers might then ignore, modify, abuse, misinterpret or even distort the intention of the envisaged educational policy changes (Kennedy, 2005; Towndrow *et al.*, 2010). Furthermore Xu (2010:50) observes that such programmes can become counterproductive as teachers get disenchanted that the more they are trained the less they can teach in the classroom.

The approach adopted for this study was a continuous long-term school-based model where teacher learning was reconceptualized or re-envisioned as an ongoing process of sense-making relating to current practices and the continual refinement of processes and content to keep pace with the speed of educational landscape changes (Engeström, 2001; Johnson, 2010). The approach was thus onsite (*in situ* or situated) and authentic (realistic) in relation to the practical constraints and inadequacies experienced by teachers, schools and students as an endless mutually constitutive cycle. It appeared logical to position teacher professional development within the context of the teachers' workplaces as that enabled more to be known about the web of local factors that influenced teachers and their classrooms (Towndrow *et al.*, 2010). However, merely being school-based, does not by itself guarantee success and sustainability. For example, Loughran and Gunston (1997) argue that even when teachers are eager to improve their practices within their own schools and classrooms, their professional development work might peter out once the intervention has come to an end. A concern for success and long term sustainability is consistent with the view that a useful, non-exploitative partnership should

not only be cognizant of the local context and needs of the learners, educators and researchers but should also aim to enhance self-reliance rather than become an excessive drain on the resources of the unsuspecting recipients (Ernest, 2007b).

One approach to bring about such transformation in education is to adopt models of teacher professional development that emphasise not just practical competence but also reflexive competence (Fraser, Killen & Nieman, 2005). In western educational philosophy the idea of reflection has its genesis in the work of Dewey (1983) who distinguished between 'routine' actions of practitioners (driven by rules, tradition, habit, authority and institutional prescriptions that suppress imagination, courage and the desire to experiment) and 'reflective' actions (guided by constant self-appraisal, inquiry, creativity and development free from the inertia of immemorial customs).

When teachers become reflective practitioners who are able to engage in reflection-on-action (after) and reflection-in-action (during teaching) as advocated by Schon (1983; 1987) they develop the conceptual tools and capacity to inform and improve their own practice on a sustained, critically reflective and reflexive basis. McLaughlin (1999) cautions, though, that critical reflection is not always significant in itself, but only in so far as it is adequate, insightful and relevant. We argue that when that reflection takes place in multiple contexts (personal, interpersonal and collaborative) it can lead to the emergence of professional learning communities (Wenger, 1998). Moreover, mathematics teachers, for example, are often reported to work in isolation from each other (Gellert, 2008). Galvanized by a positive transformation of identities, Wenger's communities of learning/practice are capable of collective and collaborative self-reflection which can lead to more sustainable change. Such a prospect should bequeath to a teacher professional development initiative some 'catalytic validity'. Lather (1991:68) defines catalytic validity as the degree to which an intervention or research process re-orient, focuses and energizes participants toward knowing reality in order to transform it. Catalytic validity is considered to be a more appropriate term for describing the criteria for establishing rigour in a social world characterized by extreme complexity and unpredictability (Ernest, 2007b). It is therefore a more socially just criterion for validity in an enterprise such as education which takes many years of dedicated work and persuasion to transform.

Purpose of the study

The purpose of the study was three-fold: (a) to revisit the context-specific professional development needs of mathematics and science teachers in the project schools, (b) to periodically evaluate the extent to which the school-based SMILES intervention strategies addressed the identified needs in the project schools, and (c) to refine and adapt the intervention on the basis of feedback obtained and changes in the curriculum. More specifically the study sought to answer the following research questions?

- What continuing professional development (CPD) needs were identified before the commencement of school-university SMILES partnership?
- To what extent had the identified needs been met by the beginning of the second year, half-way through and at the end of the second year of implementation?
- How did the feedback inform subsequent implementation strategies of the SMILES partnership?
- What, if any, was the impact of the intervention on student achievement?

Methodology

Research design

A mixed-methods approach was adopted in this study to enable triangulation. Hence the data were collected through interviews and questionnaires and subjected both to quantitative and qualitative analysis.

Population of project schools

Five secondary schools and ten feeder primary schools were involved in the SMILES project consisting together of about 150 mathematics and science teachers and with a learner population of about 14,000. The majority of the learners were drawn from socio-economically challenged communities which included migrant informal settlements, rural farm labour and working class township communities. All of the schools were either in quintile 1 or 2 and their demographics consisted almost exclusively of coloured and black learners.

Three of the five secondary schools had permanent principals while one had a newly appointed principal and the fifth an acting principal. Three of the feeder primary schools had newly appointed principals.

The intervention primarily targeted numeracy and literacy in the Foundation Phase (Grades 1–3), Mathematics and Natural Sciences in the Intermediate and Senior Phases (Grades 4–9), and Mathematics, Mathematical Literacy, Life Sciences and Physical Sciences in the Further Education and Training Phase (FET) (Grades 10–12).

Data sources

Table 1 shows the data collection method and the research question it addresses.

Table 1 Data collection method and research question

Research question	Data collection method
Q.1. What were the teachers' needs?	Needs identification questionnaire
Q.2. To what extent had the identified needs been met at various stages of implementation?	Semi-structured interview, workshop evaluation questionnaires, mid-term programme evaluation questionnaires, End-of-year-two evaluation questionnaire
Q.3. How did the feedback inform implementation?	Synthesis of info from all instruments
Q.4. What was the impact on student achievement?	National assessment results, e.g. National Senior Certificate results

Data analysis

The semi-structured interview results were categorised according to factors facilitating or constraining the intervention efforts within and beyond the school's control.

The questionnaire feedbacks from teachers were tested for internal reliability using the Cronbach alpha reliability index and further graphical and statistical analyses were performed.

Results

Needs assessment questionnaire results for teachers

Thirteen Natural Sciences teachers responded to the needs assessment questionnaires being 81% of the participating junior secondary school teachers. The teachers expected their participation in the SMILES project to benefit them in several ways that included: ‘support with content base’, ‘how to present topics in an interesting manner to learners’, ‘assist with understanding of practicals’, ‘to be able to spend more time doing practical work with learners in their classrooms’, ‘to be more conversant with NCS learning outcomes and assessment standards’, ‘assessment techniques — how and what to assess’, ‘to improve in their resourcefulness, problem solving skills and networking with teachers in other schools’, and ‘to participate in excursions to places of scientific interest’. Teachers also listed topics in which they needed more support and these included, as an example from natural sciences: evolution, organic chemistry, genetics, diversity, change and continuity.

Factors identified as inhibiting the effectiveness of mathematics and science education in the project schools included: lack of resources (ranging from worksheets, handbooks, past examination papers and textbooks all the way to laboratory facilities, laboratory perishables, equipment, libraries and technological infrastructure), lack of skills for alternative ways of doing practicals, excessive workloads (administrative paperwork required by OBE, e.g. portfolio requirements for teachers and learners), large class sizes, poor learner discipline, low levels of parental involvement and support, poor command of the language of instruction by learners, and perceived inadequacies of support by school management.

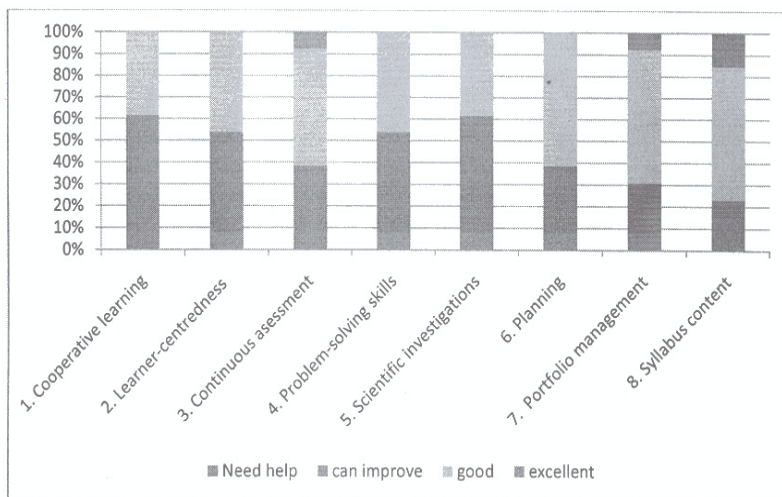


Figure 1 Self-evaluations of teachers' knowledge and skills

Figure 1 shows that the teachers felt they needed to improve their skills in the orchestrating cooperative learning approaches, enacting learner-centred pedagogy, adopting problem-

solving approaches to the curriculum implementation, and promoting inquiry oriented teaching through scientific investigations, and implementing the continuous assessment policy as required by the National Curriculum Statement and Assessment Guidelines. However they felt confident when it came to planning, portfolio management and syllabus content.

Semi-structured interviews with school management teams

A total of 15 SMTs were interviewed representing 100% of the project schools. Each team was represented at least by the principal. The results from the interviews pointed to the following benefits/strengths of the SMILES intervention:

- The laboratory equipment and calculators distributed to schools were greatly appreciated for addressing the problem of lack of resources.
- There was appreciation in the primary schools that literacy and numeracy had been included in the SMILES after the Foundation Phase had initially been left out.
- High schools appreciated the inclusion of their feeder primary schools in the intervention initiative following their previous recommendations.
- Primary schools were keen to improve their systemic test results for Grades 3 and 6 to meet their WCED targets.
- High schools were equally keen to improve their Grade 12 National Senior Certificate results to meet WCED targets.
- Staff were keen to work towards the improvement of their school results.

Schools were beset with considerable challenges in their efforts to meet expected levels of learner achievement. The identified constraints included:

- Unstable leadership in some schools (principals either acting or new in their positions)
- The very low socio-economic status of the school community — poverty, especially in non-fee paying schools.
- Lack of parental cooperation in some communities as shown by poor attendance at meetings.
- Inadequate support from subject advisors.
- Excessive assessment of learners demanded by the Department of Education seen as taking away too much teaching time.
- Poor learner discipline, especially in high schools, compounded by large class sizes.

Workshop evaluation(s) — a case of the Senior Phase Natural Science teachers

Figure 2 shows results from one of many workshop evaluations used in the SMILES project. In this particular instance 16 Senior Phase Natural Science teachers attended the workshop during the first quarter of the second year. They were drawn from both the primary and secondary schools in the project since the Senior Phase (Grades 7–9) straddles these sub-systems in SA. This systemic arrangement poses some coordination challenges and the workshop specifically brought these teachers together so that they could dialogue on their expectations of each other within and across the primary/secondary divide. (The problem is more easily managed in combined schools but often passes unnoticed in separated schools.)

Questions 1–6 sought feedback on the relevance of workshop materials (link to the curriculum, suitability for use by educators, learner-centredness, suitability for effective knowledge construction and skills development, and enactment of cooperative learning). The results show that questions 4–6 were more satisfactorily addressed than Q1–3. Questions 7–11 focused

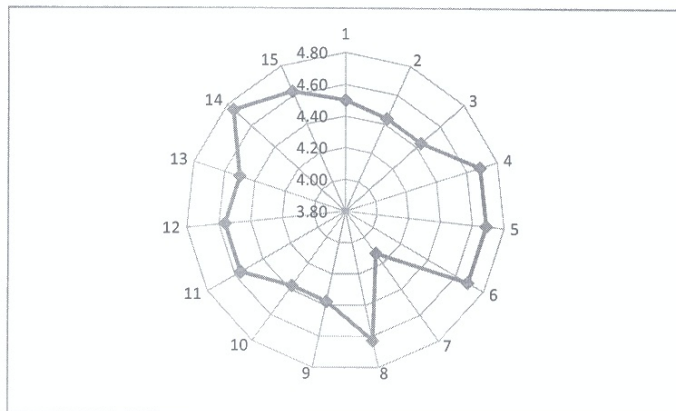


Figure 2 Joint Life Sciences workshop evaluation

on venue suitability (Q.7) and the facilitators' presentations (8–11), and the results show that there was low approval of the venue but high approval of the hands-on activities of the (Energy) workshop. Questions 12–15 focused on judgment concerning knowledge gains, content topic relevance, personal professional development and confidence gains. The lowest approval rating was in the relevance of the topic while the highest impact was perceived in terms of personal professional development value.

The reliability indices of the questionnaire (Cronbach alpha of 0.911, Split-half correlation of 0.924 and a Spearman-Brown prophecy of 0.961) indicated a relatively high level of internal consistency. On the whole the teachers reported the workshop to have been of great value (overall mean of 4.53 and standard deviation of 0.366).

Mid-term evaluation by teachers

A total of 35 (Mathematics and Mathematical Literacy) teachers responded to a mid-term/ mid-way evaluation of the SMILES project questionnaire and Figure 3 shows the results of the average score on a five-point Likert scale. Questions related to school visits (Q.1–6), workshop effectiveness (Q.7–12), supply of learning materials (Q.13–17), ICT skills (Q.18–20) and self-confidence (Q.21). The questions had a high internal consistency (Cronbach alpha of 0.891; Split-half (odd-even) correlation of 0.886 and Spearman-Brown prophecy of 0.940).

On the whole the teachers were satisfied with the progress of the intervention (overall mean of 4.25 and standard deviation of 0.67). The teachers were most satisfied about the value of classroom visits, followed by workshops, ICT skills development and learning materials distribution in descending order. (NB: The low level of agreement about learning materials was due to the fact that teachers were only given learning materials relevant to the subject and phases taught).

End-of-year 2 evaluation

The end-of-year-2 SMILES project evaluation questionnaire was administered at an end-of-year colloquium attended by 93 teachers from the project schools, the fund manager and the

local Department of Education circuit manager. It sought to gather feedback on the sustained nature of the implementation (Q.1), satisfaction with the mode of training delivery (Q.2), opportunities for individual and collective reflection (Q.3 & Q.6), school-basedness (Q.4 & Q.8), opportunities for collaboration (Q.5 & Q.8), learner-centredness (Q.7), curriculum (Q.9), content knowledge and pedagogical skills (Q.10, Q.12 & Q.13), follow-up support (Q.11) and respect for the professional integrity of teachers (Q.13). Taken together, the questions had a relatively high level on internal consistency (Cronbach alpha of 0.883, Split-half correlation of 0.840, Spearman-Brown prophecy of 0.913).

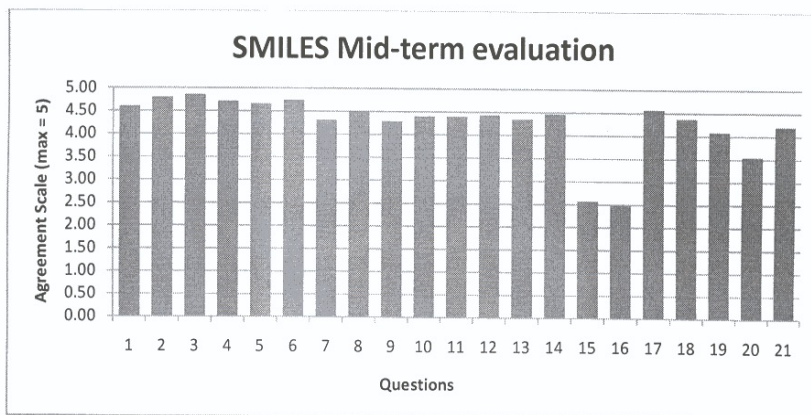


Figure 3 SMILES mid-term evaluation

Figure 4 shows judgments on programme effectiveness at the end of the second year as perceived by 28 secondary, 32 primary (intermediate and senior phase) and 33 'other' teachers in the partnership schools. Mathematics and science teachers in secondary schools were consistently the most satisfied (average of 4.576) about the impact of the intervention programme. Teachers in the 'other' category (average of 4.359) included principals, deputy principals, Foundation Phase educators and those teaching subjects other than mathematics and science. Teachers in the intermediate and senior phases in the primary schools were the 'least' satisfied about the impact (average agreement of 4.321). What was most appreciated overall was the professional development value of the intervention (Q.11) while accessibility to and inclusivity of all teachers (Q.14) ranked the least. On the whole however there was a relatively high approval rating of the effectiveness of the intervention (average of 4.412).

In the open-ended section of the questionnaire teachers recommended that more workshops should be held and that the intervention partnership should be extended to 'other teachers within' and beyond the project schools. This was consistent with the quantitative feedback. The initiative was also described favourably by teachers as the following examples show:

"This project served as the strong backbone for my school, it brought back all that I thought was lost (motivation) ... enhances commitment, powerful tool for intervention."
(Teacher A)

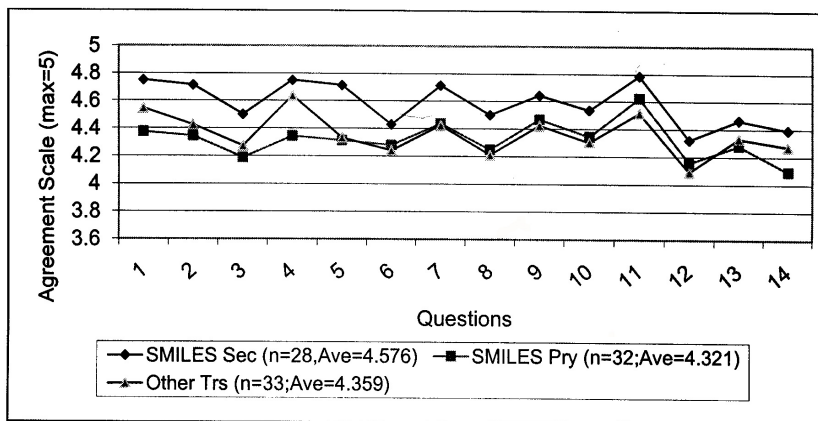


Figure 4 End-of-year 2 feedback

“They not only develop educators but the learners also. They bring teaching aids with them to put across the content. The facilitators are there for us all the time.” (Teacher B)
“The facilitators deliver on promises... they are knowledgeable, energetic and have a passion for their subjects.” (Teacher C)

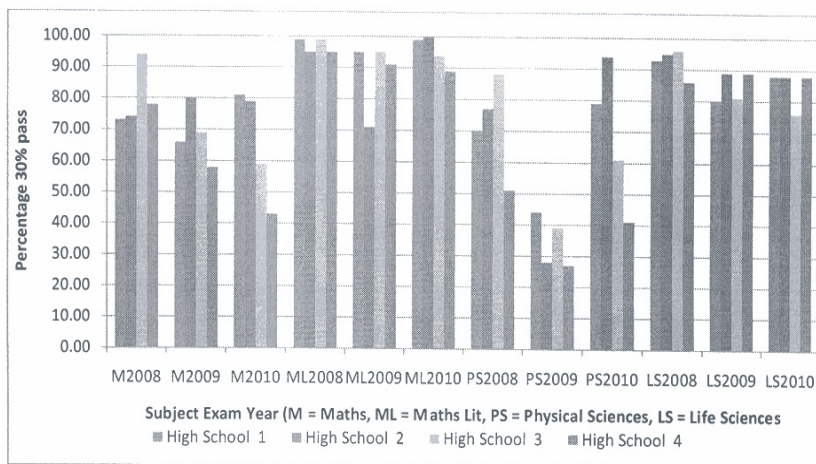


Figure 5 Progression in maths and science learner achievement

Impact on learner achievement

Figure 5 shows the mathematics and science learner achievement progression in four of the five high schools over a period of three consecutive years (2008-2010).

Discussion of results and their implications

The purpose of this study was, firstly, to revisit the professional development needs of mathematics and science teachers in selected disadvantaged schools of the Cape Winelands District in the Western Cape. Secondly, the study sought to continuously evaluate the effectiveness of the school-based mathematics and science teacher professional development programme implemented in partnership with the university. Thirdly, the study sought to adapt the programme to changing needs on the basis of feedback obtained as well as changing curriculum requirements.

From the needs identification questionnaire it was clear that teachers were in honest need of support with content and innovative pedagogy, experience of hands-on practical approaches so they could develop positive feelings of professional self-efficacy in handling their lessons. Teachers in disadvantaged schools are not deliberately deficient, but in genuine need of professional support and capacitating, not threats of punitive evaluation, which they detest for historical reasons.

Semi-structured interview results for school management teams also revealed that principals and SMT members were vulnerable to performativity and managerialist tendencies that ignore the abject poverty, skewed linguistic and socio-economic exigencies impacting negatively on their professional mandates. Unsurprisingly, while most of the primary schools welcomed the extension of the intervention to the Foundation Phase and secondary schools welcomed the extension to their feeder primary schools, there were complications. High staff turnover was complicated by inevitable resistance to change, unwieldy class sizes, inimitable resource limitations, paucity of parental support and the unpredictability of learner commitment. Regarding sustainability after the termination of the partnership all schools attested to the fact that they still needed the intervention for a few more years before they could be weaned off. This was evidence that although the partnership schools were desperate for assistance they were also realistic in their expectations.

The workshop evaluations revealed that affording teachers a forum to interact and share experiences, ideas and fears with peers from different schools tended to reduce professional isolation and encouraged the formation of Wenger's (1998) learning communities or communities of practice for mutual support. The setting of joint-cluster test papers also enhanced to build a common identity among schools. The workshops and the ensuing relationships enabled teachers to see the value of synergy in the struggle to bring about improved opportunities for marginalised communities. Conducting occasional joint primary and secondary school subject teachers' meetings/workshops created the prospect and promise of a smooth transition from primary to secondary by identifying and bridging potential gaps in curriculum content and banishing the old us-versus-them blame game.

Furthermore, while teachers understood the value of educational tours of places of scientific interest it was heart rending to learn that many of them in these disadvantaged schools were visiting the museum, the science centre, and the medical school for the first time when their students were taken courtesy of the SMILES project. This has serious implications for pre-service and in-service teacher education to deliberately afford student teachers and in-service teachers the opportunity to experience science and mathematics outside the four walls

of the classroom.

Although the semi-structured interviews showed that teachers were apprehensive about class visits at first, mid-term questionnaire results revealed that class visits made by the university facilitators and the subsequent intra-school-discussions were extremely supportive of teachers' needs eventually. This was more so when they realised that the university was sourcing and supplying them with learning materials, laboratory equipment and even scientific calculators for learners. Teachers also acknowledged personal growth in resourcefulness through improvisation. The moral was that under-resourced and understaffed schools impose a double-edged burden on teachers committed to an education for social justice. (In one feeder informal settlement primary school, the facilitators even supplied fans for the prefabricated classrooms at the makeshift site, to moderate classroom temperatures during hot summer days.) The indication by teachers that they had a lot of faith in the university facilitators because the latter kept their promises and were knowledgeable has implications, not just for DoE subject advisors but also for the envisaged new DoE unit on mathematics, science, accounting and English language education.

The end-of-year-two evaluation results afforded the university facilitators the opportunity to reflect on the impact and long-term sustainability of the project. The high levels of teacher confidence engendered by the partnership was testimony that school based CPD initiatives that are responsive to teacher development needs can accentuate the expectancy-value in understanding the interplay of motivation and expectations relating to changes in teacher behaviour (Pop *et al.*, 2010). The clarion call by some teachers for the partnership to be extended to other subjects and other schools evinces the degree to which teachers can be selflessly supportive of efforts to deliver quality education. Mathematics and science education for social justice should acknowledge that teachers' professional dignity needs to be respected and nurtured. To expose, threaten or penalise teachers for situations that they are victims rather than masters of can only be counterproductive. This conclusion was consistent with Bantwini's (2009) finding that a district CPD model (for natural science teachers) that did not address the various challenges and complexities within the district created several challenges that negatively impacted on the success of the new curriculum reforms.

The 2009 Physical Science results were lower than normally expected suggesting that the exam papers were more difficult than in previous years and the year after. Such a pattern rendered the National Certificate Examination to be an unreliable year to year measure of learner performance. This pattern was in line with the national trend. Two high schools (1&2) marginally improved their performance in mathematics over the three-year period. The other two (3&4) regressed in their achievement in mathematics suggesting that there were unaccounted for internal local factors. The variance in candidate performance from year to year was also evident in other subjects although on a lesser scale. Further monitoring of progress was required.

Conclusion and recommendations

While this study makes no claims to generalizability to all situations of disadvantage it offers some insights into the potential benefits of school-based CPD university-school partnerships. The study also highlights the limitations of duration of implementation held in dynamic tension with high expectations from funders who expect quick results and education authorities who want quick evidence of 'what works' as models of best practice. While some of the student outcomes may appear unimpressive in the limited time, it should be noted that raising student

achievement is ‘a complex task that takes many years to accomplish’ (Crasco, Kim, Bride, Leavitt, Thomas & Weiner, 2005:20). It can be added that a socially just improvement in student achievement is also a complex task that takes many factors to accomplish.

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