CASME'S APPROACH TO THE SUSTAINABILITY OF SCIENCE EDUCATION IN SOUTH AFRICA

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Abstract

This paper is derived from activities carried out by CASME (Centre for the Advancement of Science and Mathematics Education) in Kwa-Zulu Natal, South Africa. CASME aims to address historical, systemic imbalances inherent in the South African education system by improving and sustaining the quality and accessibility of Mathematics and Science education. It does this in a three-pronged way: in-service training; school based support and the provision of resources for Mathematics and Science teachers in poorly resourced teaching communities. CASME concedes that educator change is a long-term project, but that it is a necessary precursor to gains in learners' performance. The focus of this paper is an evaluatory account of CASME's Dinaledi Life Sciences intervention programme. This programme functions within the context of curriculum redress and a variety of national and provincial strategies for addressing deficiencies in the teaching and learning of mathematics and science in South Africa. We used the educators' and tutors' experiences of this programme and their reasons for their particular experiences to provide data to evaluate the programme. A naturalistic, mixed mode case study approach was used. 101 Life Sciences educators and 5 tutors were the participants in this research. Data collection instruments included test papers, questionnaires and tutor programme reports. Findings suggest that many educators rated the organisation; content and facilitators work in the programme as good. Of significance is that 99% of the educators' content knowledge was improved as evidenced by the pre-test and post-test data. The educators and tutors also made suggestions about how the programme could be improved. We conclude with implications of professional development interventions on the sustainability of science education and the role that independently funded University outreach units can play in achieving the objective of sustainable development in Science Education.

Key words: *science education, professional development,*

1. INTRODUCTION

CASME (Centre for the Advancement of Science and Mathematics Education) is an outreach and teacher professional development unit of the School of Science, Mathematics and Technology Education at the University of KwaZulu-Natal, South Africa. CASME aims to address historical, systemic imbalances inherent in the South African education system by improving and sustaining the quality and accessibility of Mathematics and Science education. It does this in a three-pronged way: in-service training; school based support and the provision of resources for Mathematics and Science teachers in poorly resourced teaching communities. CASME concedes that educator change is a long-term project, but that it is a necessary precursor to gains in learners' performance. One approach is the provision of vacation workshops.

CASME was recently commissioned by the Department of Education (DoE) under the banner of the Dinaledi project to provide in-service training for Life Sciences educators.

The Dinaledi (meaning stars in Sesotho) initiative is part of the DoE's ongoing strategy for developing Science and Mathematics capacity in South Africa. This initiative was initially aimed at providing focused support to selected educators and schools in order to double the number of learners passing Mathematics and Science at Grade 12 level. CASME was engaged in the Dinaledi Project by providing learning materials and in-service training to educators where they were exposed to innovative teaching methods and hands on practical experiences. The educators attended workshops where they were engaged with key areas of the National Curriculum Statement Grade 12 syllabus in Life Sciences. The aim of these workshop sessions was to: 1) assist educators with new topics as well as topics that are deemed problematic; 2) assist educators in adequately preparing for the year's teaching by setting milestones; 3) assist educators in conducting experiments and to 4) assist educators in conducting high quality assessments. As this was an intervention programme we were interested in the nature and structure of the programme, educators and tutors experiences of the programme and the reasons for their particular experiences.

2. LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

The following is a brief review of literature in the field and the concepts that are used to frame the research.

2.1. Education in South Africa

There is a direct correlation between a nation's wealth and its scientific and technological capacity (World Science Forum 2007). In South Africa we need to make a concerted national effort to promote science and technology as a means of improving living standards. The most effective way of taking our country forward is to engender in our young people an enthusiasm for science and technology. South Africa more than ever needs qualified individuals who will use their skills and entrepreneurial spirit to enable our country to compete internationally with the best. We need a new generation of young minds, skilled in and passionate about science and technology, working to put us on the global technological map.

However, some schools in South Africa do not have well-trained science educators, nor do they have resources or laboratories. Also, educator to learner ratios in a class is often so high that the educator only conducts practical demonstrations, where possible, in science. This together with other factors, e.g. lack of funds has had a significant negative impact on the number of students entering the tertiary field. To help alleviate this problem it is believed that educators need to place more emphasis on STEM (Science, Technology, Engineering and Mathematics) careers and encourage learners to choose STEM careers. For this to be achieved the educators themselves need to be suitably qualified and confident in the teaching of science and in so doing preparing learners for tertiary education in these fields. Educators need support through in-service training as well as developing their content knowledge and their pedagogic skills. CASME provides such training by introducing educators to ideas and strategies to encourage and motivate their learners.

In many cases educators in South Africa are victims of their own previous education and they generally teach in the manner in which they were taught. Furthermore, many educators were neither exposed to nor did they learn large chunks of content knowledge during their schooling (Stears & James, 2004). We need to heed the words of Wu (1999, p. 539) who states that "you can't teach what you don't know". There is thus the need to

influence educators' perceptions and understanding of Life Sciences with the aim of changing the way they think about it so as to increase the 'global economic and scientific competitiveness of our country. The underlying assumption is that if we change educators' perceptions and understanding of science then these educators will help change learners' perceptions and understanding of science. However the question that needs to be asked is: How do educators improve their ability to retool teaching, update curricula, integrate new research methodologies into instruction, meet the growing list of the socio-political needs of students and raise test scores? The most frequent answer is professional development.

Few could argue with the view that more is expected from today's educators than ever before. Policy documents, state accountability plans, and the current job market all point to the fact that continuous school improvement is not optional but required. The goal of many of the changes in science education in South Africa is to present a curriculum that will help prepare learners for lifelong learning and provide equal opportunities for all learners (Nicol 2002). However the question that needs to be asked is: How do educators improve their ability to retool teaching, update curricula, integrate new research methodologies into instruction, meet the growing list of the socio-political needs of students and raise test scores? The most frequent answer is professional development.

2.2. Professional Development

The extent and depth of educators' knowledge in all its forms has been the focus of much research (McDonough, Clarke & Clarke, 2002). The thinking is that if 'quality' science educators were produced, they would then produce more students entering the tertiary field of sciences. However educators themselves may have marginal interest in proposed change and although there has been research done on educator thinking, it is not clear how studies of educator thinking may be of use in improving the quality of educator preparation programs (Clark 1988). We know that the educator is important as a guide and a leader who has the potential to transform and enlarge the knowledge and understanding of learners (Griffiths 2000). We also know that educators themselves are the primary initiators of their own development hence educator empowerment ought to be brought to the fore (Harfitt and Tavares 2004). Furthermore, educators' professional communities are important sites for professional learning and can thus be considered as powerful micro cultures. Establishing professional communities of practice whereby educators have the opportunity to co-construct understanding of policy messages and reform proposals is an important strategy for sustainable educator development.

Professional development refers to "activities to enhance professional career growth." Such activities may include individual development, continuing education, and in service education, as well as curriculum writing, peer collaboration, study groups, and peer coaching or mentoring (Ferraro, 2000). School reformers are paying considerable attention to the role that effective professional development can play in improving the teaching of mathematics and science and as schools continue to move into different phases of educational reform, one factor that is consistent in each school plan is the need for professional development.

Educational reform requires educators not only to update their skills and knowledge but also to totally transform their roles as educators. It is through professional development that educators could learn new roles and new teaching strategies to improve student

achievement. Through these in-service professional development programmes educators have access to an expanding body of knowledge with respect to the content area, teaching techniques, and meaningful, engaged learning for students. This increased access and engagement with information, along with the current focus on educational standards that emphasise in-depth learning experiences and problem-solving abilities in science has made it crucial for educators to be prepared to implement change in the classroom.

Thus professional development is located at the intersection of educational reform, educator work and educator learning (Bredeson, 2002) hence the professional development of educators is considered as a core theme in the landscape of educational reform. A restructuring of educator preparation programmes has been widely recommended as a means to better prepare educators for inclusive settings (Laarhoven, Munk, Lynch, Bosma & Rouse, 2007). In light of these concerns, educators are seeking to develop strategies for assessing the results of their efforts (Hammond-Darling 2006). Whilst this may be the case one cannot assume that all problems can easily be solved by professional development, rather many issues need to be considered, amongst them being social context, resources, infrastructure, etc.

Many educators in South Africa comment on how the physical environment of the classroom has a strong influence on what they can do in the classroom. Physical environment includes the number of learners, the seating arrangements, and the amount of space available to move around in the classroom amongst others. Furthermore, educators also comment on how social and political factors influence the range of strategies they can use in the classroom. Thus the challenge for those responsible for educator development is to find ways to strengthen and support activities within the social settings of individual educators. Teddlie and Stringfield (1993) suggested that effective schools in different social class contexts displayed different characteristics depending on the socio-economic context in which they operated. This implies that the need to consider the social context is important.

In addition to understanding learning and development in social and cultural contexts, professional knowledge bases include strong emphasis on content-specific pedagogical knowledge (Hammond-Darling 2006). Especially with changes in the science curriculum in South Africa where educators are required to teach new content that they have previously not encountered before. Thus effective professional development means building a culture of ongoing learning for the educators and learners in a school.

3. METHODOLOGY

A naturalistic, evaluatory, interpretive case study was used. A naturalistic inquiry was used as the goal of the researchers was to understand reality. (Cohen, Manion & Morrison, 2000). According to Cohen, Manion & Morrison (2000, p. 181), the interpretive research paradigm assumes that people's subjective experiences are real. A case study approach provided the opportunity to concentrate on a specific instance or situation (Cohen, Manion & Morrison, 2000), namely the Dinaledi Intervention programme. A qualitative case study is characterized by "detailed description of situations, events, people [and] interactions … from people about their experiences, attitudes and thoughts" (Patton, 1980, p. 20) about a situation. The educators and tutors experiences of the programme fulfil this case study requirement.

Four Grade 11 and 12 educators from each of the 84 Dinaledi schools in KwaZulu-Natal were invited to the teacher training workshops. Only 101 teachers arrived for the training. These teachers together with 5 tutors were the participants in this research. The educators and tutors were informed that their comments etc were to be used to compile a report on the project. The educators and tutors were assured of anonymity and confidentiality.

The data collection instruments included an educator test, questionnaire, tutor report and project report. The questions for the pre and post-test were based on the material that was discussed during the sessions. The educator questionnaire had categories of questions which were linked to the organisation, content and facilitator features of the programme. The data was collected and then analysed. According to Cresswell (2003, p. 190):

> the process of data analysis involves making sense out of text and image data. It involves preparing the data for analysis, conducting different analyses, moving deeper and deeper into understanding the data, representing the data, and making interpretations of the larger meaning of the data.

The process involved capturing and transcribing the data. The collected data was analysed using an ongoing process of inductive analysis (Lincoln & Guba, 1985). All the data was read and separated according to the responses that the educators made in the questionnaire and the tutors made in the report. The separated responses from questionnaire questions and report were analysed using content analysis (Tesch, 1990). The test marks were recorded as percentages and a comparison was made of the pre and post-test results.

4. FINDINGS AND DISCUSSION

4.1. Description of the Dinaledi Intervention Programme

The Life Sciences workshop of the Dinaledi Intervention comprised a one week residential training programme which was scheduled for the school holidays that preceded the start of the school year. A residential programme is one where educators from different schools and different areas convene at a central venue. Accommodation at the University in the student residences and meals were provided which maximised the training time. Campus facilities such as classrooms, lecture theatres and laboratories were utilised for the academic programme. Educators were divided into five classes allowing for close, small group interaction. Grouping was done according to district of origin with neighbouring districts combined. This clustering was aimed at facilitating networking between teachers that could practicably be sustained and developed into a learning and support community beyond the residential training. The daily programme comprised three two hour sessions and an early evening session set aside for extension activities, presentations by relevant experts, discussions with DoE subject advisors and viewing of exhibits.

The programme structure combined theory and practical work with related extension activities. The focus of training was an intensive engagement with two topics, namely Evolution and Biotechnology in the secondary school Life Sciences curriculum. The topics selected were based on input from the DoE at various levels including senior managers, subject advisors, subject committees and examiners. The particular topic

focus was additionally guided by the fact that both would be taught and examined for the first time as part of the new Grade 12 South African school curriculum. Training material in the form of a comprehensive topic guide was produced and distributed to participating teachers at the start of the programme. The guide was developed according to the National Curriculum Statement for the Knowledge Area and Learning Outcomes. In addition facilitators utilised sets of presentation materials including PowerPoint presentations and a variety of overhead transparencies. For the practical work component of the programme simple equipment and tools were showcased which would be easily replicable in an under-resourced educational environment.

4.2. Educators and tutors experiences

The educators' pre and post- test results are presented in conjunction with their evaluation and comments about the programme. Table 1 below:

Categories for the test scores	Pre-test results % of educators (n = 101)	Post- test results % of educators (n = 101)
< 10 - 20%	10	0
< 21- 50%	50	12
> 51 – 80%	28	58
> 81 – 100%	0	22
Did not write	12	8

Table 1: Pre and post-test results for educators

The educators' post-test results indicate an improvement in their content knowledge. What is significant is that 5% of the educators who achieved < 20% (lowest group) in the pre-test, achieved >50% in the post-test and 1% of the lower group achieved 80% in the post-test. The variance ranged from 4 to 64. The mean variance for the group with <10 - 20% is 37, while the mean variance for the group > 81 - 100% is 38.

99% of the educators improved in their content knowledge. One educator achieved 8% less in the post-test. There is no explanation for this. The educators' improvement in their knowledge is supported by comments that they made like "the workshop eased some teachers fears and anxiety about the new sections of the curriculum"; "CASME should organise more workshops of this nature to expose more teachers … and introduce them to different strategies of handling difficult and new concepts in a syllabus."

The educators rated the workshop organisation, content and facilitator features. The ratings for some of the criteria are presented in the table below:

Workshop rating criteria	% Educators strongly agree	% Educator agree	% Educators disagree
1. Organisation of workshop			
a. Good workshop preparation & organisation	37	58	5
b. clear formulation of workshop aims	47	46	7
c. achievement of workshop aims	33	61	5
2. Content of workshop			
a. relevance of workshop materials & activities	45	50	7

b. relevance of workshop activities in informing teachers	44	48	6
3. Facilitator features			
a. knowledgeable and well prepared	55	43	2
b. facilitator clearly explained the purpose of each session	64	33	2
c. facilitator help educator gain confidence to implement	56	37	7

Table 2: Educator ratings of the workshop

Clearly, more than 90 % of the educators agreed and strongly agreed with the rating criteria. They also stated that the "workshops were content oriented with well equipped, friendly and energetic facilitators who went out of their way to assist educators". The suggestions that teachers made about how the workshops could be improved focused on organisation in terms of time, working with basic areas of the curriculum which the teachers did not understand, dealing sequentially with topics as they are presented in the curriculum, requests for lesson planning and generic assessment ideas.

Three tutors stated that the outcomes for the programme were achieved, one was not sure and one did not respond. The reasons that tutors gave for their responses were: "more work required to deal with educators' attitudes and views and also on how they can deal with the topics." "the pre and post-test results shows a tremendous change in the educators' knowledge". The challenges that tutors experienced during the programme were: "teachers did not have sufficient prior knowledge that was essential for the module." "Teachers lacked basic skills e.g graphing". Teachers also expressed to tutors that they were going to experience problems of trying to teach evolution as this is so different from what learners know about life.

5. CONCLUSION AND IMPLICATIONS OF THE RESEARCH

In striving for a model of teacher professional development that has the potential for sustainable impact several factors were considered: relevance of topics to teachers needs; maximising depth and breadth of content coverage; building support networks amongst teachers within locally accessible clusters; modelling approaches and use of resources that are inexpensive and replicable; creating opportunities for interaction and networking with DoE support structures; exposing educators to activities and presentations that extend and contextualise their understanding of curriculum content.

Realistically, universities are primarily focused on the formal training of educators and research and therefore cannot assume the role of an in service training provider to the extent that is necessary in South Africa. The DoE, whilst officially responsible for support and academic development of its workforce, simply does not have the capacity to deliver broad-based ongoing professional development. However, an independently funded outreach unit such as CASME which has close relationships with a University, the DoE and teachers themselves has the potential to be the bridging agent between the three. It is able to draw on the institutional support of the University, the will of the DoE and its own popularity with rank and file teachers.

If the successes observed in the Dinaledi Life Sciences programme are replicated in the other projects in which CASME is engaged then it is possible that a basis for sustained science education development is being established. This model, which is attempting to

address educators' cognitive and pedagogical development and promote the formation of local professional communities of practice is worthy of further empirical investigation.

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