Instructional functions in large, under-resourced science classes: Perspectives of South African teachers

GILBERT ONWU AND NEWTON STOFFELS

GILBERT ONWU *is a Professor and Head of Department of Science Mathematics and Technology Education in the Faculty of Education of the University of Pretoria where he also is Chair of the School of Teacher Training. He obtained his PhD in Chemical Education at the School of Chemical Sciences University of East Anglia, UK. His research interests are in problem solving in chemistry, the application of cognitive development research in science and mathematics education and the teaching of science and technology in under-resourced large classes.*

NEWTON STOFFELS *is a teacher educator and researcher at the Department of Science, Mathematics and Technology Education at the University of Pretoria. His research interests include curriculum policy analysis and implementation, particularly as it relates to science education. His PhD thesis (2004) focused on the instructional decisions that science teachers make during complex curriculum change.*

Abstract

Following the implementation of the new outcomes-based Curriculum 2005, teacher competence in teaching reform-based science in large classes is one of the challenges in the continuing reform of South Africa's education system. Most school teachers have little experience, meagre training and are operating in large and poorly resourced science classrooms. As part of the understanding of the teaching and learning that takes place in such contexts, this study focuses on science teachers' perspectives on their current classroom practices. Data collected through surveys and questionnaires to participating science teachers revealed their perspectives of the reality of teaching large under-resourced science classes and the typical patterns of classroom teaching. The essential components of their instructional functions are identified together with the implications these have for teacher education.

Introduction

The movement to reform South Africa's education system through the implementation of Curriculum 2005 is well under way. Curriculum 2005 envisages changes that are both wide and sweeping. It seeks to switch to a system of education that is based almost entirely on rote memorization of content knowledge to one in which knowledge and skills are put to use and applied for the enrichment of the individual and, by extension, the broader society. The publication of a National Qualifications and Assessment Policy Framework (NQAPF), and Revised National Curriculum Statements (RNCS), has provided the blue print for change, and is intended to improve the quality of science education in line with the principles of outcomes-based education and training (National Department of Education, 1995; 1997).

The revision of the science curriculum towards a more open, learner-centred inquiry-based system of OBE is expected to transform the classroom practices of teachers and the student's learning environment. To successfully implement this curriculum, it is essential to have teachers who are knowledgeable in science, confident in their ability to conduct science investigations and with the necessary pedagogical skills and resources to guide and facilitate inquiry-based learning through an outcomes-based education (OBE) teaching approach.

Given that in most South African schools, as is the case in most African countries, a major constraint that limits effective science teaching, is large under-resourced classes (Onwu, 1998; 1999), it would be particularly useful for any diagnostic study to focus on this reality in terms of the instructional demands the new OBE curriculum makes on science teachers. To do so, we argue, would provide a realistic context not only for research that will illuminate the factors that affect teacher and learner performance in such classes, but also help to redirect policy and practice. Such redirected research is expected to lead to a search for realistic practices to improve student performance in classroom situations that will remain a reality for the foreseeable future, rather than research that demonstrates the inability of our teachers to perform in such situations. Research has reinforced the notion that large class instruction is a complex process affected by a multiplicity of factors (Onwu, 1998). In the South African context, the envisaged change from a traditional content-driven curriculum, to one that is more learner-centred and inquiry-based will no doubt impinge significantly on a number of factors affecting teacher's practice. Such factors will of necessity include the availability of learning materials, instructional facilities, and teacher competence in teaching reform-based science in large classes.

An important part of understanding classroom teaching and learning is being aware of the perspectives of the teacher practitioner in those classes. As a basis therefore for designing appropriate needs-based intervention for teacher change, this study focuses on science teachers' perspectives on their current practices in teaching large under-resourced classes. In particular, we ask: How do teachers of large, under-resourced science classes, at the threshold of major curricular and instructional changes, view their current classroom practices? What do science lessons to groups of 50 to 100 learners in poorly resourced learning environments typically look like from the teachers' perspective? How do teachers of large under-resourced science classes describe their best lessons and why? We believe that those questions are topical, given that in South Africa, as in most African countries, the phenomenon of large classes has become a permanent feature of our schools.

Background

The extensive body of research on curriculum reform abounds with compelling evidence that changing teachers' classroom practices is a difficult, slow, uneven and for some even impossible assignment (Fullan, 1996; Cohen, 1990; Mclaughlin, 2000). The process is even more complex with comprehensive 'second order changes' (Fullan, 1993), which entail major shifts in the knowledge, skills, attitudes and classroom routines which teachers have developed over a number of years. Following intensive classroom-based research on instructional change, Cohen (1990, 63) concludes that teachers are 'historical beings,' who cannot just simply divorce themselves from deeply ingrained routines, practices and beliefs cultivated over a number of years. Moreover, as they attempt to reach out to practice an innovation, 'they reach out with their old professional selves, including all the ideas and practices therein' (Cohen, 1990, 64).

These insights have important implications for teacher change and development in the context of teaching large classes, for they mean that to assist teachers to make sense of instructional changes, there has to be an informed understanding of the 'old professional selves' of teachers. this also suggests that before we can even begin to proffer guidance, we need to understand what exactly teachers are doing in their classrooms, why they are doing it, what their particular constraints are, and how they deal with them. It is against this backdrop that this study attempts to look at how science teachers who have to grapple daily with the unique challenges presented by poorly resourced large classes, cope with this phenomenon. We believe the outcomes of the investigation would provide useful insights with practical implications for teacher education, given that South Africa is currently phasing in more progressive, outcomes-based instructional policies, known to be inordinately challenging to implement in large classes (Fullan, 1996; Onwu, 1998; Hargreaves, 2001). Marnewick and Spreen's (1999) comment, for example, that the prime reason why OBE reforms have not been very successful is because they fail to understand the active contexts in which teachers receive and have to make sense of instructional policies.

At the level of the teacher practitioner those observations perhaps translate into the questions, "Are teachers themselves willing to make changes, and if so to what extent are they able to do so?" First, teachers will change if they think that a change is both necessary and in their own interest and of their learners (Onwu & Mogari 2004). Second, physical resources are certainly one major factor that can contribute to or inhibit change (Beeby 1966; Rogan 1999). Poorly or under-resourced teaching and learning conditions can confine the best of teachers to the mindless routine of rote memorisation. As Beeby (1966) notes:

A teacher with fifty to eighty children in a small bare room, with no equipment but a blackboard, a piece of chalk, and a few miserable dog-eared texts, with not enough pencils and pieces of paper to go around … can scarcely be expected to encourage the unfolding of personalities and the emergence of creative minds (76).

The specific concern with large under-resourced science classes springs from our observation that despite the high premium placed on, and the colossal investments made in promoting access to science education amongst South African learners, there appears to be a policy void on how to address the particular constraints of teaching large under-resourced science classes, which still pervade post-apartheid South Africa. In this article we do not attempt to enter into the debate on whether class size affects learner performance, or to highlight the complexities of teaching large science classes. Neither do we intend to proffer 'magic bullet' suggestions and recommendations of how teachers are to become proficient in OBE under those contexts. Instead we provide a snapshot of what is happening in these classrooms, analyse the virtues and faults as seen and experienced by the teachers themselves, and report on what these teachers view as their proudest moments or best practices.

Theoretical framework

Following an extensive study of the classroom practices of teachers, Rosenshine and Stevens (1989) employed the concept of 'instructional functions' to describe the key instructional behaviours of teaching well-structured rule-oriented subject matter areas such as science. They concluded that the key instructional functions of teachers are:

1. Reviewing and checking previous day's work (checking homework, re-teaching when necessary, reviewing relevant past learning).
2. Presenting new skills and content, providing short statements of objectives, overview, and interspersing questions within the presentation to check for understanding.
3. Guiding student practice through a high frequency of questions and overt student practice, teacher checks for understanding by evaluating student responses and giving additional explanations.
4. Providing feedback and correctives to monitor learners for systematic errors.
5. Giving independent student practices until learner responses are firm, quick and

automatic; alerting students that homework will be checked, actively supervising their work.

6. Systematically reviewing, on a weekly and monthly basis, previously learned material, and giving frequent tests.

This largely behaviouristic but not exhaustive list has been usefully applied as a framework in many situations. However the positivistic trend to reduce the complexities, multidimensionality and unpredictability of classroom life to a sequence of small steps is not the whole answer, and does raise a few questions. It is likely that in many teaching and learning situations the context of learning is far too complex. There are many variants of instructional functions that hinge largely on the pedagogical style of the teacher, the particular grade and subject matter taught, and the learners themselves. And so teachers and learners cannot be presumed to be constant factors. But having said that, the strength of the construct of 'instructional functions' lies in that it provides a useful theoretical lens to look at the particular patterns and routines that characterise the teachers' method or practice. We therefore consider it a useful theoretical framework to help represent and analyse how teachers of large science classes say they typically experience their daily lessons.

What is a large class?

What constitutes a large class has been a bone of contention amongst scholars, researchers and practitioners (Onwu, 1998). Governments of countries in sub-Saharan Africa and influential donors such as the World Bank frequently restrict their definitions of large class to pupil-teacher ratios (PTR's). From that perspective what is considered a 'large class' is the exceeding in number of students of the specified teacher learner ratio. To the extent that issues of teaching large classes are contextual, many educational practitioners in Africa hold different views and beliefs about what is a large class (Onwu, 1999). A survey of a group of African science educators, teachers, and researchers associated with the Large Classes Node Project at the University of Venda, South Africa, on their conceptions of what is a large under-resourced class in science, led to the emergence of 'typologies of large science classes in under-resourced classrooms' in an African context (Onwu, 1999, 125). The purpose of the survey was to elicit from these practitioners multiple perspectives of a large science class and a poorly resourced classroom in their diverse multiple sites and in their own words. Thus from the emerging typologies of large science classes in under-resourced classrooms it was possible to characterise a large class in one of many ways as follows: "A large class is one where the majority of characteristics and conditions present themselves as interrelated and collective constraints that impede meaningful teaching and learning" (Onwu, 1999, 126). Any one or all of these would mark such a learning environment:

- Lack of physical space for movement due to overcrowding;
- diminished opportunities for all learners to participate actively in the learning process;
- the impersonalising of teaching;
- teachers resorting to predominantly lecture and teacher demonstrations;
- excessive workload, and a long homework assignment turnaround;
- limited opportunities to meet individual learner needs for self-activity and inquiry, motivation, discipline, safety and socialisation.

However, for this study we adopted any one of those characteristics including the technical view of teacher: learner ratio as our entry point for identifying such science classes. Considering that the specified or recommended teacher: learner ratio of secondary schools in South Africa is 1: 35, we particularly looked at teachers with classes in excess of 50 learners. As is shown later, the average number of learners for most of the respondent teachers is 60, with a few having to contend with up to 100 learners in a normal size classroom (5 x 7 meters).

Research methodology

This research followed a mixed methods approach, drawing on both qualitative and quantitative evidence. Convenience sampling led us to fifty-three (senior secondary) teachers of large science classes who attended a 3-day regional impact workshop held at the University of Venda (UNIVEN) to review the state of research on the teaching of large under-resourced science classes (Proceedings of the launch of the Node and the Impact Workshop, 2002). Towards the end of the workshop, the 53 teachers completed a comprehensive semistructured, open-ended questionnaire on what their classroom practice typically looks like. Apart from questions aimed at eliciting biographical profiles of individual teachers and their schools, the teachers were also prompted to reflect on how their science lessons were typically structured and sequenced, how learners were involved, the availability and use of resources, what they regarded as their best practices, and how they scheduled follow-up work. Exemplars were provided to give them an idea of how they should elaborate on their classroom practice. The exemplars did not, and were not meant in any way to limit the amount and types of data that the respondents wished or volunteered to share with the researchers. Hence from the spontaneous and sometimes unstructured responses we were able to gather detailed descriptions that comprised thick data. The respondents were given an unlimited time to complete the questionnaire.

We realise, however, that in the South African context an important study such as this that hopes to provide valid insights into the vital aspect of how teachers of large under-resourced science classes operate, needs to be founded on *thick, rich descriptions* of these teachers' daily practices. We feel that our data may be limited in this regard, primarily because the questionnaire data have not been triangulated with extended classroom observations to see how teachers' professed instructional practices relate to what actually happens. However we are confident that in the context of this study that describes a thin slice of the reality of teaching large science classes, we gleaned useful and instructive data. The information and insights generated from the teachers' responses provide reliable diagnostic information that is consistent with recent calls for more descriptions of teaching from the practitioner's view, and the lamentation of the dearth of scholarship of what actually happens in classrooms and why teachers do what they do (Tobin, Kahle & Fraser, 2000).

Data analysis and results

Profile of the schools and teachers

The 53 respondent teachers were spread over 53 secondary schools in Region 3 of the Limpopo Province. This is one of the poorest provinces in South Africa, and one with the most urgent need for improvement in education delivery. Inadequate facilities, poorly qualified teachers, increasing enrolment, overcrowded classes and very few teachers who qualify in science and mathematics are some of the main issues requiring attention. The particular challenges faced by the respondents attached to the 53 schools are even more poignant when one considers that 63% of these schools have teacher: learner ratios of 1:60, with the average number of classrooms in which these large classes can be accommodated being thirteen (13). Forty-seven schools (89%) had no library facilities, whereas forty-three of them (82%) did not have any science laboratory to speak of. Moreover over half of these schools (57 %) operated without electricity, whereas 74 % did not have flush toilet facilities. The following data presented in Tables 1-3 give a broad overview of the characteristics of the science teaching personnel in those schools, as well as the average size of their science classes.

Table 1: Highest science qualification

B.Sc.	B.Sc. (Hons)	Grade 12 School Certificate	3rd-Year Diploma	4h Year Teachers' Diploma	None
4	1	21	17	2	4

Table 3: Secondary science teaching experience

1-5 Years	6-10 Years	11-15 Years	16-20 Years	21-25 Years	26 + Years
7	21	13	3	5	0

Table 3: Highest number of learners in class in last three years

31-40	41-60	61-80	71-90	91-110	111-130	131-150	+150
3	15	14	17	3	4	1	3

The reality of teachers' large science classes

As can be gleaned from the tables, many science teachers in a majority of the schools have had 6 to 15 years of teaching experience. The kind of teachers we are dealing with, as well as the environment in which they operate, clearly shows that our respondents' difficulty with large science classes is compounded by a number of other disabling factors. Many schools as reported, function without basic facilities of electricity and flush toilet, with school buildings characterised by broken window panes, dilapidated chalkboards, and an inadequate number of learner desks – so much so that learners often sit on the floor. It is evident (ref. Table 1) that many teachers are not qualified to teach secondary science, let alone in large under-resourced science classes with learners whose home language is different from the instructional medium (English). We note that many of the participating teachers are teaching at high school with a primary school teaching qualification, and that the highest science qualification of close to 40 % of them is on senior certificate level. The limited science content knowledge of the science teachers sampled, is in line with the evidence from both developed and developing countries. This seems to suggest that this deficiency is a major global problem (Taylor & Vinjevold, 1999; Gess-Newsome, 1999).

Teaching is by nature an onerous task, with teachers daily experiencing an almost overwhelming "classroom press" for immediacy, multidimensionality, simultaneity, and personal involvement with learners (Huberman,1983). These pressures seem to be all the more acute in teaching large under-resourced science classes, especially when one considers the following responses from the fifty-three teachers to the question of what their major classroom challenges are. Listed in the order of those cited, from the most to the least are:

- Classroom control and management (maintaining order and discipline)
- Severe shortage of science laboratory equipment (apparatus, practical kits, laboratories)
- The lack of individual learner attention due to the large number of learners
- Shortage of support materials (stationery, textbooks, teachers' guides)
- Shortage of classroom space to accommodate large number of learners
- Restriction of movement in the classroom
- Lapses of concentration on the part of the learner
- Excessive marking load

- Difficulty in remembering learners' names.
- Truancy and ill-discipline
- Difficulty in teaching inquiry science to, and/or conducting practical laboratory exercises with large classes.

The respondents do however claim that they are willing to change in line with the principles of OBE but that they are mostly overwhelmed by the enormity of the task.

Biography of typical lesson in large science classes

From teachers' descriptions of what their lessons typically look like, a number of interesting revelations of what happens in a typical science lesson in large, under-resourced classes in South Africa emerged. Admittedly, teachers were not always very comprehensive in the lesson descriptions, despite being given a detailed exemplar of what was required. Nevertheless, it is apparent that they share some commonalities with Rosenshine and Stevens' (1989) notion of Instructional Functions.

Classroom and lesson organisation

A large proportion (68 %) of respondents noted that their science periods last between 30 and 40 minutes. Some (13%) had single periods of about 50 minutes, with the rest double periods of 120 minutes duration. Most of the classrooms used for science are normal, non-laboratory rooms 6 by 7 meters in size. All the teachers complained about the insufficient number of desks which they attributed partly to the inability to fit a sufficient number of desks for 60 learners into a room of that size, and partly to the inadequate supply by the State. The situation that is described by a respondent seems to typically exemplify one of the challenges of teaching large science classes in the province: "They, the learners use bricks to sit on because ... the doors and some of the chairs have been vandalised ... it is uncomfortable for them to write while sitting on the brick."

With regard to how learners are arranged or organised in the classroom, there appear to be two main configurations. Most teachers have rows of desks and chairs stacked close together, while the remaining have students in groups of 5 to 8, facing each other. According to the teachers, learning opportunities were hampered and learning was slowed down by an inadequate supply of furniture. At some of the schools, broken furniture had to be propped up against the wall and learners had to share desks and chairs. Such disabling conditions did not allow good prospects for group work or practical activity. Not surprisingly, learners reportedly react to inadequate provision of furniture by moving about in class resulting in a high noise level during lessons. An illuminative description of the context in which some science teachers teach in large under-resourced science classes came from one of the respondent teachers who wrote:

> My classroom was (is) under a tree on an empty space. We have a small piece of chalkboard with no stand. It was so difficult to write on windy days because leaves and small branches usually fall down ... we have 68 learners and 50 chairs, so some sit on a dry log and stones ... writing on their legs is common. Rainy days they don't have classes. There are no resources at all.

Instructional functions of a typical non-practical science lesson

The teachers themselves gave an account of what features typically characterise their teaching methods in non-practical science lessons. Twenty-eight per cent (28 %) of the respondents indicated that they typically start their lessons by spending 5 to 10 minutes reviewing the previous day's homework. This is done either by asking learners to write their answers on the board, or to shout them out. A few of the respondents indicated that they simply write down the correct answers on the board for learners to copy, with little discussion taking place. Most indicated (61%) that they did not physically check whether individual learners had done their homework or not because of the number involved. Only 10% of the teachers indicated that they actually ensured that learners corrected their homework. Forty per cent (40 %) of respondents noted that they commenced their science lessons by reflecting on the previous day's work, both to check learners' understanding and factual recall, and to link this with the day's planned lesson. For example, a teacher wrote: " I ask questions for about 5 minutes to test if the previous day's work is well understood. If not, I repeat, but if it is well understood, I start a new concept." When introducing new science concepts, most teachers (77%) responded that they routinely ask learners general, introductory questions related to the new concept, not only to lay a foundation on which to build, but also to engender interest and excitement. Only 9% indicated that they actually write down the topic and objectives (learning outcomes) of the lesson on the board. Most respondents (82 %) continue to intersperse their lesson explanations of the new concepts with questions to the learners. As exemplified, "I ask oral questions during and after the lesson to check if the topic or concept is well understood". Where learners show a lack of comprehension, either by having incorrect classroom responses or homework answers, or being unable to recall the previous day's work, close to 89% of the respondents asserted that they re-explain, or re-teach the trouble-area, using the learners' mother-tongue to facilitate and enhance understanding: As explained "language problem is also there, so I use the mother tongue to further explain science concepts". Not surprisingly, all the respondents remarked that most of their learners are not proficient in English, the language in which the textbooks in use are written.

Sixty-seven per cent (67 %) of the respondents indicated that they habitually write down copious notes on the chalkboard. Learners are instructed to copy these notes in their notebooks, because of the lack of textbooks. The teachers' apparent dependence on the textbooks can also be gleaned from this remark by one of the respondents:

> We are ever running short of textbooks, so some students have no books. Most of the lesson is spent taking notes and this disadvantages most learners as they cannot double concentrate (listen and write).

On the question of consolidation of lessons, 77% of the participating teachers reported that they did this by giving learners homework in the form of written exercises taken from the textbooks or previous examination question papers. Clearly many of the instructional functions of today's non-practical science lessons in large under-resourced science classrooms do not appear to be that different from the pre-Curriculum 2005 norm. The teaching methods predominantly used are traditional in the sense of being teacher-centred, textbook-based, and whole-class oriented. Generally, teachers lead from the chalkboard or textbook. Learners participate in lessons through the question and answer technique and this strategy dominates a greater part of the lesson followed by teacher talk and copying of notes. Little group work or other learner-material or learner-learner interactions occur. The absence of intellectually stimulating activities, which promote higher order thinking skills such as investigation, curiosity, understanding relationships, is a marked feature of these teachers' lessons as described. What comes across is a pervasive lack of physical facilities and learning support materials, as well as teacher resourcefulness in the schools.

Instructional functions of a typical practical lesson

The majority of respondents (78 %) indicated that practical periods in which scientific apparatuses or student science investigations ought to be used, are allotted on the timetable twice a week. As reported, only 9 % of the sampled respondents do laboratory exercises at least once or twice a term. A worrying 22 % of them do not do any practical work at all, attributing this to a lack of science resources and the difficulty of undertaking scientific inquiry with groups of 60-100 learners. This following statement exemplifies the golden thread that runs through all the descriptions: "I conduct practical only occasionally because not all or enough chemicals and equipment are available"

Nearly all (89%) respondents invariably perform practical experiments as teacher demonstrations, which learners are asked to follow closely. These demonstrations are then accompanied by verbal questions to the learners. But one teacher did confess that: "In the lesson I would have to demonstrate the practical, while learners remain silent. "

At the end of the demonstrations, these teachers then hand out self-designed worksheets, or those provided in the textbook that learners complete either in class, or as homework and in groups. As one respondent explains: "I prepare worksheets, distribute to every learner, but advise them to work in groups. Because of the lack of materials and chemicals, the learners only see the demonstration done by me the teacher and they in turn will complete the worksheet."

Another teacher wrote: "I have three classes of 61 children doing general science. For one teacher to manage equipment for such large classes is logistically impossible (children take the test-tubes and put them in their pockets, or break them). Administering the equipment is too difficult."

Clearly the classroom teaching approach of independent learner practice, or independent learning in science is one that most teachers are either not familiar with or do not practice in science lessons.

Teachers of large science classes' ideas of their 'best lesson'

Interestingly all 74% of the participating teachers who responded to the question of the lesson, that in their opinion was the best they had taught in recent times, described a learner-based activity in which teacher involvement was minimal. The following extracts are given as illustration:

> learners were grouped and given a task of calculating the potential difference between the charge and the current that flows in the circuits which they had to connect and work on.

> I gave them strings to measure angles, using chairs, tables and desks in their classroom because they were readily available.

> I asked them to make black tea, and to cut lemon and squeeze the juice into the tea, and observe what happens to the colour of the tea.

Another interesting dimension was what the respondents had to say why they would regard that particular lesson as their best. Nearly all described their rationale for selecting the lesson as their best, in terms of how learners had responded to the lesson activities. None of them went into any lengthy justifications of how well prepared they were, or how much effort they had put into collecting the requisite resources or on how conversant they were with the lesson topic. Instead they described how well learners understood and did the work, or how much they enjoyed it and could remember it some time after it had been done. As illustration, teachers wrote:

> They (the students) all showed an understanding of what they were talking about and what they were so eager to carry out.

> When given exercises after the lesson, they all did well.

> Learners were eager to do the work, and enjoyed doing it unlike other days.

This preoccupation with the quality of the work their learners had achieved, and the fun they had doing it, despite the constraints of their environment, stands out as an encouraging factor. The performance of learners in science and mathematics in the province and in South Africa generally is a long, thin pyramid. We have the normal distribution of learners who do very well; a number who are coping at matriculation level (Grade 12), but by far the majority who do not have the confidence in their competence in mathematics and science. In rural and black schools in general, mastery of science and mathematics is exceptionally low. "In certain places it is possibly six or seven grades below where it should be, Grade 12's are only functioning confidently at a Grade 7 or 8 level, and so are the teachers" writes one education expert.

Discussion

Looking at the data in the light of Rosenshine and Stevens' (1989) concept of instructional functions, a certain pattern of teaching in resourced large science classes in South African schools seems to emerge. Whereas Rosenshine and Stevens' (*ibid)* framework highlighted 6 major instructional functions, we could only identify the following three in our respondents.

1. Introduction of the lessons by either checking homework, or by reflecting on the previous day's content through question and answer session. Homework checking is done either by learners writing their answers on the board, or orally bouncing them off the teacher. Teachers routinely do not check individual learners' homework. Rather a pattern that emerged was making sure that learners copy the correct answers in the notebooks.
2. Presenting new content or skills by providing short statements of the topic and by asking introductory questions to probe and link learners' prior knowledge with the new concepts to be taught. Where the lessons are to be done practically, teacher demonstrations are the norm. Learners are then expected to observe, with the teacher periodically asking questions related to the demonstration. For most of the respondent teachers, little, if any, individualised independent learning, or learner-centred teaching takes place. From their comments on the difficulty with classroom management, poor discipline, and lack of physical facilities in the classroom, it is perhaps understandable that teachers would make such feeble attempts at involving their individual learners more actively. However, the majority of 'best lessons' by the teachers are described as highly learner-centred and inquiry-oriented. In sum, physical constraints coupled with a deep-rooted lack of confidence in managing activity-based science teaching and learning limit the variety and effectiveness of reform-based instructional functions.
3. The lessons are typically concluded by an effort at consolidation, chiefly in the form of homework, and oral questions and answers. The main source of homework is predominantly questions from the textbooks, which learners either write down from the chalkboard or are given in the form of duplicated worksheets.

Clearly a glaring difference between what we found in the context of teaching large under-resourced science classes and Rosenshine and Stevens' (1989) findings is the complete absence of "guided student practice" and "independent student practice." These practices imply much learner-centred activity involving among others learner-material interactions, which as the respondents suggest, seem almost impossible in an overcrowded and under-resourced classroom.

The next important element of concern is the quality of teachers themselves. A paradox emerges. The relatively poorly qualified science teachers are a prime cause of present problems. Yet, education experts agree that teachers are one of the few ways out of the problem. At the same time it is a lengthy process to produce better teachers and a hard task to retain them. In the interim what is needed is to find ways to assist practising teachers to deal with large under-resourced science classes.

In the final section of the survey questionnaire respondents were asked a series of questions about practical steps that would help improve their science teaching under the given circumstances. At provincial and school district level they identified in-service courses on inquiry-based learning for the teaching of large poorly resourced science classes; improved monitoring and support by curriculum advisors and officials to build on the science content and process skills the teachers already have. At school level, they identified strong school leadership; good school management; reasonable class sizes; and a supportive learning environment for learners. In the classroom itself, the participating teachers identified access to extra learning materials and facilities for learners; teaching aids; and more personalised contact with learners.

Conclusion

That teachers of large, under-resourced science classes resort to instructional functions dominated by lecturing and demonstration, and their confessed inability to manage activity-centred practices within existing physical constraints, accentuates the difficulty these teachers have and will have in shifting their practices towards a more outcomes-based teaching approach. Certainly, the phenomenon of large classes is a veritable 'frame factor' (Posner, 1995, 17) that will no doubt impact on the way and the extent to which teachers who operate in these contexts make sense of the instructional changes and demands inherent in the policy shifts towards outcomes-based teaching.

On the face of it, the three-tiered pattern of instructional functions, which this study has found to be dominating current teaching of large science classes, is at odds with the professional competence required of teachers in the new dispensation. Science teachers may hear about 'constructivist teaching', 'outcomes-based teaching' 'inquiry science learning', but for them they appear to be no more than just words. They do not understand them and have certainly never seen them practised under the trying conditions they have to deal with. Few teachers have been through a better model on which they can base their own teaching and neither have the trainers. This South African experience of the policy-practice divide echoes some of the mismatch between policy and actual classroom practices identified in other African settings (Olorundare, 1990; Prophet & Rowell, 1990). Similarly, Cohen and Ball (1990) report on the implementation of progressive instructional policies in the USA, and they raise a pertinent question that might well be applied to teachers in our study: "How can teachers teach a mathematics that they never learned, in ways that they never experienced?" (352). In this study the identification of the instructional functions of teachers of large under-resourced science classes is a promising and useful tool in determining where teachers are on the didactic – constructive teaching continuum. This has implications for how in-service training and state support teacher education programs are structured and implemented. We believe that the success of learner-centred instructional reforms in large under-resourced science classes hinges on how well the active contexts of teachers of such classes are understood. We agree with Gwimbi and Monk (2003) that for too long science teachers' complaints that their classroom contexts limit, shape and direct their pedagogic choices, have gone unheeded.

Our concern about what appears to be a policy void on how to address the specific constraints of teaching in large under-resourced science classes, would seem to stem from what Carrim (2001) refers to as the 'homogenising' tendencies of South African policy-making, whereby the multiplicity of contexts and identities is ignored and issues are dealt with in generalised and homogenised ways. This 'one size-fits-all' tendency will simply not work. Certainly, this study has served to remind us that once a teacher's pedagogical style (instructional function) has become entrenched 'it has a resilience that is almost independent of changes in government, major curricular reform or even changes in teacher training' (Tabulawa, 1997, 194). What is called for is the need to focus strategically on helping science teachers bridge the gap between curriculum intentions and classroom implementation under the prevailing conditions.

References

Beeby CE 1966. *The quality of education in developing countries.* Cambridge, MA: Harvard University Press.

Carrim N 2001. From teachers to educators: Homogenizing tendencies in contemporary South African educational reforms. *International Journal of Educational Development,* **21**, 45-52.

Cohen D 1990. A revolution in one classroom: The case of Mrs Oublier. *Educational Evaluation and Policy Analysis,* **12**(3), 327-345.

Cohen D & Ball DL 1990. Policy and practice: An overview. *Educational Evaluation and Policy Analysis,* **12**(3), 347-353.

Fullan MG 1993. *Change forces: Probing the depths of educational reform.* London: Falmer.

Fullan MG 1996. *The new meaning of educational change.* Cassel: London.

Fuller B & Snyder CW 1991. Vocal teachers, silent pupils? Life in Botswana classrooms. *Comparative Education Review,* **35**(2), 274-294.

Gess-Newsome J 1999. Secondary teachers' knowledge and beliefs about subject matter and their impact on instruction. In Gess-Newsome J & Lederman NG (eds). *Examining pedagogical content knowledge.* Dordrecht: Kluwer, 51-94.

Gwimbi EM & Monk M 2003. The study of classroom practice and classroom contexts among senior high school Biology teachers in Harare, Zimbabwe. Science Education, **87**, 207-223.

Hargreaves A 2001. Cultures of teaching and educational change. In Biddle BJ, Good TL & Goodson IF (eds). *International handbook of teachers and teaching.* Dordrecht: Kluwer.

Huberman M 1983. Recipes for busy kitchens. *Knowledge: creation, diffusion, utilization,* **4**, 478-510.

Lockheed ME & Verspoor AM 1991. *Improving primary education in developing countries.* New York: Oxford University Press.

Marnewick L & Spreen C 1999. Dancing with the monster: Mastering the steps of OBE in the Northern Province. *Unpublished.*

Mclaughlin MW 1998. Listening and learning from the field: Tales of policy implementation and situated practice. In Hargreaves A, Lieberman A, Fullan MG & Hopkins D (eds). *International handbook of educational change*. Dordrecht: Kluwer.

National Department of Education 1995. Curriculum Framework for General and Further Education and Training. Pretoria: Government Printer.

National Department of Education 1997. Outcomes-based Education in South Africa: Background Information for the Educators. Pretoria: Government Printer.

Olurundare S 1990. Discrepancies between official science curriculum and actual classroom practice: The Nigerian experience. *Journal of Educational Policies,* **5** (1),1-19.

Onwu GOM 1999. Inquiring into the concept of large classes: Emerging typologies in an African context. In Savage M & Naidoo P (eds). *Using the local resource base to teach Science and Technology: Lesson from Africa.* AFCLIST. October 1999.

Onwu GOM 1998. Teaching large classes. In Savage M & Naidoo P (eds). *African science and technology education. Into the new millenium : Practice, policy and priorities.* Cape Town: Juta.

Onwu GOM & Mogari D 2004 Professional development for Outcomes-based Education implementation: The case of UNIVEMALASHI, South Africa. *Journal of Education for Teaching,* **30**(2), 160-177.

Prophet RB & Rowell PM 1990. The curriculum observed. In Snyder CW & Ramatsui PT (eds). *Curriculum in the classroom. Context of change in Botswana's Junior Secondary School Instructional Programme.* Macmillan: Gaborone.

Posner GJ 1995. *Analyzing the curriculum.* 2nd Edition. New York: McGraw-Hill.

Rogan JM 1999. The implementation of Curriculum 2005: Mapping out a research agenda to drive professional development in systemic reform. In Fennema E & Taole K (eds). *Proceedings of the Second Joint Conference.* NSF USA and NRF Pretoria.

Reeves C 1999. Are teachers likely to achieve the natural science outcomes for Curriculum 2005. *Journal of Education,* **24**, 45-61.

Rosenshine B & Stevens R 1989. Teaching functions. In Wittrock M (ed.). *Handbook of research on teaching* 3rd Edition. James Bossey: New York.

Tabulawa R 1997. Pedagogical classroom practice and the social context: The case of Botswana. *International Journal of Educational Development,* **17**(2), 189-204.

Taylor N & Vinjevold P (eds). 1999. Getting learning right. Johannesburg: Joint Education Trust and Department of Education.

Tobin K, Kahle JB & Fraser BJ 2000. Learning science with understanding: In search of the Holy Grail? In Tobin K (ed.). *Looking into science classrooms.* James Bossey: New York.