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ACTIVE LEARNING APPROACHES IN ZIMBABWEAN SCIENCE AND MATHEMATICS CLASSROOMS

Rudo Kwari
Mutare Teachers College
David K. J. Mtetwa
University of Zimbabwe

Abstract

The aim of this study was to find out whether secondary school mathematics and science teachers are using active learning strategies in their teaching. Ten teachers and nine teachers were observed teaching mathematics and science, respectively. Their knowledge about teaching for active learning and the constraints that impact on them were assessed through subsequent interviews. Although the results showed that the teachers' knowledge of active learning is consistent with literature, only incidental aspects of active learning were observed in the lessons. The teachers identified a range of constraints, including those of a curricular, socio-economic, logistical, and professional nature. The potential for increasing the level of active learning in Zimbabwean science and mathematics classrooms exists. In-service education could make a significant contribution towards the practical realisation of this goal.

Introduction

One of the reasons given for the poor results in science and mathematics education in Zimbabwe is the quality of classroom teaching, particularly the approaches used in instruction (Nziramasanga, 1999). The Cockcroft Report (1982) and the National Council of Teachers of Mathematics (NCTM) (1989, 1991) have raised similar concerns about mathematics education in British and American schools respectively. Engels (1993) cites three goals of instruction namely: content coverage; understanding and problem solving; and positive attitudes and equitable outcomes. Content coverage is not a real problem in Zimbabwe as most teachers aim at, and succeed in, completing the syllabus. It is the other two goals that do not seem to be getting adequate attention. A number of factors, such as shortage of qualified teachers, time, space, materials and poor teaching strategies or approaches, could be contributing to this inadequacy. Research needs to be conducted to establish approaches that can be promoted in order to achieve all the three goals in the face of all these problems. Active learning strategies, for instance, could engender teaching and learning of mathematics and science that makes the learner involved in the learning process, and not be a passive recipient of information.

(Dodge, 1996) explains that: "Active learning puts the responsibility of organising what is to be learned in the hands of the learners themselves." This, in turn, may reduce passiveness by students. Can we say that a student following worked examples in a mathematics lesson is being afforded the opportunity to construct meaning of what is being presented and be able to process and apply it in novel situations? A lot depends on how the student is involved in working out the example. Similarly, a pertinent question would be: "To what degree are students in a science lesson carrying out experiments or watching a demonstration involved to enable meaningful learning to take place?"

The Promise of Active Learning

Active learning is a situation that requires minimum factual knowledge, but a great deal of experience in using particular kinds of thinking (Smith, 1996). It is a situation in which knowledge is directly experienced, constructed, acted upon, tested, or revised by the learner. Research literature describes active learning as techniques and situations that require the students to be doing something more than just listening. This may include reading, writing, discussing, solving problems, listening, and reflecting on ideas and issues experienced. Students are involved in higher order thinking tasks such as analysis, synthesis and evaluation. It also includes such things as discovering, processing, and applying information.

Antony (1996: 350) has presented two dimensions of active learning. The *first* denotes learning activities in which students are given considerable autonomy in, and control of, the direction of the learning. These are commonly identified as investigational work, problem solving, small group work, collaborative learning and experiential learning. This is in contrast to passive learning in which students are passive receivers of information. Examples of passive learning include listening to a teacher's exposition, being asked a series of closed questions, practice and application of information already presented.

The second dimension denotes

> a quality of the pupils' mental experience in which there is active intellectual involvement in the learning experience characterised by increased insight ... It is an attitude of active intellectual

> inquiry. This concept of active learning encompasses the notions of mental effort or intentional learning, meaningful learning and metacognition. This is contrasted by passive intellectual involvement in the learning experience which is characterised by an emphasis on assimilating new knowledge through memorisation and practice.

The first kind of active learning does not necessarily translate into the second. The two dimensions of active learning are relatively independent (Kyriacou, 1996). An active learning activity can foster either an active mental experience or a passive mental experience; just as passive learning activity can foster an active mental experience by passive or active learning activities. It is noted that even when students appear to be in rote learning situations, they construct. What is important then is the nature of the constructions, which should be strong if students are to learn the desired mathematical (and scientific) data.(Antony, 1996).

Implementing Active Learning

It is widely accepted that teachers' decisions about what and how to teach are dependent upon their beliefs about roles, rules and possibilities in education, which, in turn, have been constructed via the teachers' interactions within a social context. Hence, there is a strong reciprocal link between teachers' educational beliefs and their teaching actions. Beliefs and the social context in which the teachers are operating can act as obstacles in the implementation of an active learning agenda. Jaworski (1989: 170) observed that:

> What seems ideally desirable is difficult to achieve in practice and the teachers have to struggle with implementation, … For example the tension between teacher wanting pupils to explore their own ideas and come up with their own explanations and wanting them to perceive certain mathematical results that the teacher think important.

Some of the obstacles may be a result of differences between planned and taught curriculum, the teacher's espoused theories of teaching and learning, and the enacted visions of the theories (Ernest, 1991). Teachers, according to Ernest (1991: 289) may intend and plan to teach for active learning, but

> constraints and opportunities afforded by the social context of teaching cause teachers to shift their pedagogical intentions and practice away from their espoused theories.

Teachers in the same school may have different beliefs about mathematics and its teaching, but will adopt similar classroom practices to fulfill expectations of the school. Studies show that teachers may compromise their beliefs in order to survive the conflicts between personal professional ideals and values, either explicitly or implicitly supported by the context in which they work. If teachers carry with them prior beliefs that contradict reform ideals and social messages from the larger educational context and continue to reinforce traditional goals and methods, it may be too taxing and potentially threatening for them to sustain educational reform efforts on active learning in their teaching.

Thus, although literature strongly recommends the use of active learning approaches in the learning of science and mathematics, teachers may desire, but may or may not be able to implement these ideas. "The transmission process, which depends for its success on pupils constructing their own images of what the teacher has and trying to make sense of them" (Jaworski, 1989: 170), appears to be the commonly used method in the teaching and learning of science and mathematics.

The Research Problem

There are teachers who believe that they should teach for active learning, but when faced with constraints and problems, the commitment diminishes. Some teachers may not be aware that they are using active learning strategies. Our interest, in this case, is to find out what is actually happening in the science and mathematics classroom in terms of teaching for active learning. We posed the questions (a) what active learning strategies are teachers using in the teaching of science and mathematics?, and (b) what obstacles and constraints are they encountering?

Data Generation

Twelve schools were conveniently sampled (those accessible to the researchers) to include three from rural and nine urban (six low-income and three high-income socio-economic neighbourhoods). From these 12 schools, a sample of 19 qualified and experienced teachers, (nine mathematics and 10 science), were observed teaching science or mathematics classes. Five schools had only one teacher observed, while the remainder had two each, one for science and the other for mathematics.

Lesson observations and interviews were conducted with all the observed teachers using pilot tested observation and interview guides. The observations focussed on

(a) actions within the whole class component, (b) actions within the small group/pair formats, and (c) actions within any other distinct component of the lesson. The interview probed the observed teachers' rationale for their deployment of the observed strategies, the constraints and problems of implementation, and their personal knowledge about active learning. The data were either audio-taped and then transcribed, or manually recorded on the semi-structured instruments. All the data were content analysed for patterns of involvement of active learning strategies during instruction.

Observations

Observational data indicated that all the teachers used question-and-answer (Q/A) and individual seatwork. The teachers asked mostly closed questions (naming, identification of procedure, e.g., What do we do to the equations to eliminate y?) Individual seatwork mostly took the form of written exercises. There was one exercise which took an oral and another which took a reading format. 95% of teachers used the lecture method, most of which comprised mini-lectures interspersed with Q/A, peer teaching, etc. One case of a complete lecture and another that had no lecturing (a consolidation lesson) were observed. In one of the lessons that had several moments of mini-lecturing and other activities, all the components of the lesson beautifully integrated into a single overall active lecture.

The next frequently used set of strategies were peer teaching [75%] and small group or pair work [55%]. Use of small group work was sometimes dictated by the logistics or the physical sitting provisions obtaining in a classroom, or by the need to share limited resources, e.g., a textbook [50%]. In addition, half of the small group/pair sessions observed were spontaneously formed by the students and half were organised by the teacher. There were a few instances of a teacher giving (or dictating) notes [30%], discussion of real-life examples [25%], teacher demonstrating a phenomenon [25%], individual student-initiated own note-taking/recording [20%], class discussion [5%], student experimenting [5%]. The student experimentation we saw was basically a demonstration where the teacher involved the students. The following strategies were not observed in any of the lessons: investigation, problem solving, use of games, role-play, exploration and brainstorming.

In whole class teaching, 80% of the teachers invited questions from students. However, the invitations were of a generalised (rather than specific) form, [e.g., "Do you have any questions?"] 60% of the teachers moved around during seatwork or group work mainly for checking what the students were doing or marking their work. The logistics of observing made it difficult to capture the nature of interactions between students during small group work. However, data from some small group sessions captured through audio-taping indicate fewer cases of students listening and trying to make sense of their partners' explanations, than those where the student would simply be listening and following an answer being supplied by partners.

Interviews

In interviews, the observed teachers claimed that they use Q/A (a) to facilitate syllabus coverage (with the teacher asking and answering his/her own question, if necessary), (b) to introduce or recap on some material, (c) for easy topics, (d) to find out students' prior knowledge, (e) to probe students' grasp of material being taught, (f) to involve more pupils, (g) to make students think hard, (h) for slow learners, and (i) to make it easy to manage large classes.

The teachers said they used individual seatwork (a) to check students' level of understanding, (b) for individual student assessment (both formative and summative), and (c) to fulfill school expectations and syllabus requirements.

They said they used lecture (a) depending on the nature of topic/subject, (b) when introducing a new concept or skill, (c) when it involves routine work and application (i.e. when there is nothing new to discover), (d) when the topic is difficult for the learners, (e) for fast learners who can easily absorb the stuff (f) to minimise the number of questions from students and cover ground, (g) for teacher to assist students to relate different aspects of the topic, and (h) because students want to hear the authoritative version of the teacher.

The teachers indicated the following teaching methods as some of the methods they would like to use, but are not able to do so: discovery, fieldwork, guided independent learning, practicals and manipulatives, information communication technologies (ICTs), small group projects, quizzes, research, experiments, exploration, real-life problems and readings.

The constraints they are facing include (a) lack of resources such as time, equipment and textbooks, (b) non-conducive school environments and cultures, syllabus demands, large classes, disciplinary problems (It's difficult to control the students and some could slip away to the nearby shopping centre disappear if you take them out to the field), (c) low self-confidence and lack of motivation (perhaps due to a feeling of inadequate qualifications, or poor working conditions and remuneration) [Such teachers wouldn't, for instance, bother engaging with open-ended questions], and (d) client-service relations (parents and students want to see A grades regardless of the quality of the learning methods used) [This hints that schools have taken on a business orientation].

Teachers suggested the following as ways of getting around the constraints: (a) improvisation, e.g. using teacher designed diagrams or models, (b) establishing good rapport with the students (make students like you, the teacher, and your subject), (c) involve parents, especially for discipline-related constraints, and (d) syllabus should stipulate areas requiring, say, fieldwork [This is an acknowledgment of the authoritarian effect of the syllabus document] .

Most of the teachers described their understanding of active learning in ways such as (a) pupils have to be doing something and less listening to the teacher, (b) active involvement of both teacher and pupils (the teacher triggers and the student does things), (c) pupils doing more of the work, while the teacher facilitates, (d) pupil-centred (let children focus on their learning and not how the teacher is teaching), (e) students see things happening, discover their own errors and initiate activities, (f) interactive learning, pupils exchange information and ideas, and (g) when pupils do and discover for themselves, concepts are really grasped.

Finally, teachers indicated that they teach for active learning, but do not necessarily plan for it. They teach normally and it just happens during the course of the lesson. It comes as a result of experience. They expressed the following views on teaching for active learning in mathematics and science (a) doable, but time-consuming, (b) suitable for high ability students, other students would need to be first motivated, (c) teacher has to plan for it to make it work (teachers abandon it during planning, believing it will not work due to various constraints), (d) more crucial for low ability (since the high ability grasp things anyway), (e) school culture influences how teacher delivers lessons, (f) requires both knowledge about it and teaching experience (one component alone is not enough), (g) it calls for commitment, creativity and innovativeness on the part of the teacher, and (h) important for subjects where there are practical skills [Teachers who brought out this view may be equating active learning with practical hands-on actions only].

Discussion and Concluding Remarks

First, there are aspects of active learning that were observed in the lessons, though a concern for active learning does not seem to be necessarily the driving element of the lessons. Most of the teachers confirmed during the interviews that they do not plan for active learning, it just happens in a sort of spontaneous or incidental fashion. "You see things are not moving smoothly, so you change strategy on the spot," one teacher said, describing a sort of on-line planning that immediately fuses with corrective action. Most of the reasons given by the teachers for using the 'observed' strategies are for considerations other than active learning.

Second, the strategies are also used for different purposes, reflecting different personal beliefs about the subject, learning, and teaching it. For example, some teachers said they use question-and-answer to make students think, although our observational data indicates that most of the questions used were largely low order knowledge type (*a la Bloom)*. High on the list of the teachers' considerations is the need to cover the syllabus (e.g. through use of lecture and question-and-answer), down to management of classroom logistics (e.g. through use of small groups for when texts, furniture or laboratory materials are inadequate; and peer teaching for assessment). Also, the literature suggests that one of the effects of active learning is to increase learner motivation and attentiveness. However, the teachers expressed the belief that students would need to be first motivated in order to learn actively.

Third, the teachers showed a common understanding of active learning, which according to them, was acquired at college (during their pre-service preparation). This understanding of active learning is consistent with literature. For the teachers, however, implementation is mediated by the level of student ability, available teaching time, syllabus length and other accountability requirements, school cultures, teacher commitment and self-confidence, as well as pupil and parent expectations.

In another vein, about a third of the teachers said they developed their understanding of active learning from the field, i.e. from reflecting on their own practice, whether or not they had first heard of the idea of active learning during their pre-service training days. An important corollary here is that the teachers' current understanding of active learning did not necessarily evolve through deliberate application in the field of their knowledge on active learning acquired during pre-service training. Rather, their current knowledge developed naturally from their reflection on practice. That is to say, the notion of active learning emerges in them while in the field, and somewhat independent of pre-service training, as a promising response to the self-reflective question: "How can the effectiveness of my students' learning be increased?"

It appears that the teachers are guided by what works for them in their classrooms, hence they do not necessarily plan for active learning. The strategies that the teachers were observed using in this study may not be high on the list of active learning strategies, but they can be structured to increase student participation. Teachers are aware that active learning is synonymous with student involvement in their learning. The critical question is: "What kind of involvement are we talking about?" For now, we can assume we are all referring to the kind of learner engagement that is consistent with the notion of active learning discussed in the literature. The teachers who combined lectures with other strategies, for instance, increased the level of participation of the students. We are nevertheless led to believe and surmise that the potential for increasing active learning in the schools is there. The starting point for these teachers is improving the active learning effectiveness of the strategies they routinely use. [We observed, for example, two lessons with very active learning lecture components. The teachers accomplished that through a flexible use of what they called a 'clauze' technique].

Taken together, the observations discussed above suggest that it would be fruitful, for example, for the Science Education In-Service Teacher Training (SEITT) programme to include workshops that consider live demonstration lessons, say, at the science and mathematics teacher centres, by selected expert teachers, and discussions on (a) implementing active learning teaching within real life constraints that obtain in Zimbabwean classrooms, and (b) generating practicable strategies that minimise the effects of the constraints. We believe, too, that an in-depth observational study aimed at producing a detailed description of the nature and quality of student learning engagement during the small group or, indeed, any other component characteristic of current Zimbabwean lesson structure, will add more insights into the state of active leaning in the country's science and mathematics classrooms.

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