Scientific investigations: The effect of the 'Science Notebooks' approach in Grade 6 classrooms in Port Elizabeth, South Africa

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Abstract

This study investigated whether a selected group of South African teachers could be trained to use the Science Notebooks approach successfully in their classrooms and whether the approach had an effect on the way their learners engaged in scientific investigations. The Science Notebooks approach is a formalised writing-to-learn science approach which closely models what scientists do in 'real life'. The study is based on the comparison of three Grade 6 township school teachers who participated in Science Notebooks professional development activities with four control group teachers. A mixed-method approach was used to collect data by means of classroom observations using the Inquiry-based Science Observation Scale, teacher interviews, and examining learner work using the Science Notebooks Checklist. Data generated by this study suggest that the participating teachers were able to be trained to use the Science Notebooks approach to an acceptable level and that their understanding of the approach improved during the course of the intervention. The experimental group of teachers developed the skills required to guide their learners through developing a testable question, planning their investigation, collecting data, making scientific drawings and drawing conclusions whereas the control group demonstrated no such changes. The data also suggests that the learners' inquiry skills were enhanced during the process.

Keywords: Science Notebooks, writing to learn science, science education, teacher education

Introduction

Scientific investigations, which require creative thought and systematic testing of ideas, is a critical learning outcome of the South African Natural Sciences curriculum (Department of Education, 2002). However, research has revealed that traditional teaching approaches, which focus on the mastery of content, facts and basic skills, have been the most popular approach adopted by South African teachers in the past (Taylor & Vinjevold, 1999). Similarly, the type of investigations that many of our teachers currently conduct usually consist of traditional experiments which simply verify a scientific principle that is described in their school texts (Meiring, Webb, Ilsley, & Kurup, 2005).

The traditional approaches described above are not confined to the South African context (Huber & Prost, 1995) and it has been suggested that the tenacious and ubiquitous appeal of conventional forms of teaching and practical work can be attributed to teachers' lack of pedagogic-content knowledge (Shulman, 1999; Van Driel, Verloop, & de Vos, 1998). Furthermore, it has become evident that even practical, hands-on, inquiry based activities are ineffective if they are not supplemented with 'minds-on' activities such as reading and writing (Shymansky, Kyle, & Alport, 1983; Willett, Yamshita, & Anderson, 1983; Wise & Okey, 1983). One response to the challenge to transform traditional experimental work approaches is a formalised writing-to-learn science approach which incorporates science and literacy to promote authentic investigations in science classrooms. This approach, which was pioneered in the United States of America, is the Science Notebooks approach (Hargrove & Nesbit, 2003; Miller & Calfee, 2004).

In this study we investigated the efficacy of the Science Notebooks approach in terms of both teacher development and learner achievement in the context of a South African township environment, i.e., where teaching and learning takes place in a second language in previously disadvantaged schools and communities.

Background

Authentic scientific investigations have been described as practical, problem-solving activities for which detailed instructions are not given and ones in which the learner does not know the result before the investigation (Huber & Probst, 1995). The focus of these types of investigations involve learners’ original ideas and cognitive processes such as observing, classifying and inferring, through which they have the opportunity to explain or express what happened or why they believe a particular outcome (Webb & Glover, 2004). It is understood by most that as learners investigate, plan their procedures, and manipulate their variables they need not experience the same observations or come to the same conclusions (Edelson, 1997).

In the past, despite professing to promote independent investigations, the South African General Science Syllabus promoted activities that were prescriptive and specific (Department of Education, 1983). It appears that nothing much has substantially changed in our classrooms despite the introduction of the new curriculum (Meiring, Webb, Ilsley, & Kurup, 2005). The most common approaches still usually consist of traditional experiments which simply verify a scientific principle or concept, something which Gott and Duggan (1995) argue is, in fact, not investigative at all but which is simply an illustrative practical exercise that allows learners to ‘see’ a science concept in action.

Within the type of learning environment envisioned by the new South African curriculum, children are encouraged to reveal their natural curiosity and to ask questions to clarify information they gain from their senses. These should be questions that they are sincerely interested in and for which they want useful answers. In the context of scientific investigations, it falls to teachers to guide learners to modify their general questions (which cannot be answered in the context of a classroom investigation, but which can be researched by other means) into investigable ones, as scientists do (Brunner, 1994). It is precisely the supposed ability of the Science Notebooks approach to allow learners to work in the same way that scientists do, that supporters of the process believe to be of greatest benefit (Shepardson & Britsch, 2004).

Science Notebooks

A number of researchers believe that an essential component of an inquiry-learning approach involves the documentation of activities (Campbell & Fulton, 2003; Nesbit, Hargrove & Fox, 2004). Yore, Bisanz and Hand (2006) note that although various writing-to-learn strategies have been used to communicate content knowledge gained through specific lessons, they feel that in the context of science education there are flaws in the journal and narrative strategies that have been used to date. Their reasons are that these ‘knowledge-telling’ models do not accurately reflect the transformational and recursive nature of authentic science writing, the unique characteristics of the science domains, the pedagogical purposes for writing in science, the variety of potential writing tasks in science, and the understandings of the participants (Yore, Bisanz & Hand, 2006). In turn, Science Notebooks have be described as a rich portfolio of information; including a record of learners' questions (answered or unanswered), the procedures followed, the materials used, the data that are collected and organized, as well as information gleaned from other sources (Nesbit, Hargrove & Fox, 2004). In contrast to other narrative strategies, Science Notebooks concentrate on the science endeavour; beginning with a question and ending with conclusions, rather than just the procedure of what was done and how it was done (Baxter, Bass & Glaser, 2000). A key component of the approach is to allow learners to record their thinking in a way that makes sense to them (Campbell & Fulton, 2003).

In terms of learner assessment, Miller and Calfee (2004) note that writing makes learners' thinking visible. Nesbit, Hargrove, Harrelson and Maxey (2003) contend that teachers can gain understandings of learners' prior knowledge, how they think, the origins of their misconceptions, as well as their attitudes, by assessing their Notebooks. Apart from teachers using the information generated to inform their instructional practices, the approach is well suited for learners to participate in self-assessment and evaluation of how well they conducted and understood the investigation (Nesbit, Hargrove, Harrelson & Maxey, 2003). These researchers warn that although the science notebook process involves a significant amount of student writing, the assessment of learner's work should concentrate on the scientific processes and content knowledge required of the lesson, and recommend that learner's writing, in terms of spelling, grammar and sentence structure, should not be a critical criterion of assessment.

Design

This study used a mixed-method design in order to gain insight into the ability of teachers to use the Science Notebooks approach to promote authentic scientific investigations in their classrooms. Quantitative data were generated by using the Science Inquiry Observation Scale instrument, as well as the Science Notebooks Checklist that was used to assess randomly selected learners' written work. In an attempt to interrogate the quantitative data further, data were generated qualitatively by means of interviews. The data collected included baseline information (in the form of interviews and classroom observations), post-intervention classroom observations with both the experimental and control group teachers, and reciprocal feedback sessions with the experimental group of teachers. These feedback sessions included discussion about what had been observed the classrooms, possible strategies to improve teaching strategies, and discussions between the researchers and the teachers to discuss the context of the events that took place in the classroom. All the data generated were triangulated to inform the inferences drawn and conclusions made.

Sample and Setting

Eight Grade 6 science teachers from the Port Elizabeth townships of New Brighton and Zwide were invited to participate in the research. These teachers were selected on their similar and satisfactory achievement as in-service students in the Department of Science, Mathematics and Technology Education (SMATE) at the Nelson Mandela Metropolitan University (NMMU). The eight teachers came from different schools that were broadly matched as institutions that are from previously disadvantaged communities, are similar in size and type, and which are considered neither currently dysfunctional nor excellent. Teachers were introduced to the research process and then randomly allocated to either an experimental or control group. The size range of their

Grade 6 classes was between 30 to 50 learners, which reflect the average size of classes usually encountered during work we have done in these types of schools in Port Elizabeth. Eight teachers were invited to participate, but one teacher withdrew, citing personal reasons for not continuing, just after being placed in the experimental group. As the teacher withdrew at the onset of the study this did not have any affect on either the control or experimental group, but did result in there only being three teachers in the experimental group while there were four in the control group.

Data Collection and Analysis

Baseline information on the participating teachers' classroom practice before the Science Notebooks intervention approach were generated via classroom observations, as were insights into the classroom activities of the teachers in the experimental and control groups after the experimental group had participated in the intervention approach training. Data were also generated from inspection of a sample of the experimental group's learners Science Notebooks (five children in each of three experimental teacher's classes in each of three lessons = 45 notebook entries). Interview responses were placed in categories that emerged as reoccurring themes on inspection of the data.

Baseline data

Baseline information was generated to determine what type of scientific investigations that had been occurring in Grade 6 science classrooms in the selected schools. These data were collected from all eight teachers in the form of classroom observations and semi-structured interviews. Teachers were asked in advance to conduct a scientific investigation for the observation. A pair of researchers conducted each observation using the Science Inquiry Observation Scale and came to consensus findings. Following the observation session, each educator participated in a semi-structured interview. The researcher used an open ended interview schedule to determine if the observed lesson was a typical lesson, as opposed to a prepared lesson, and to determine educator perceptions of the inquiry teaching method.

Experimental Group

After the baseline information was collected, the experimental group was invited to participate in two professional development workshops. One educator from the experimental group chose not to continue with the study; but the remaining three teachers engaged in one two-and-a-half-hour professional development workshop on scientific investigations and in a four-hour workshop detailing inquiry-teaching strategies and the theoretical and practical aspects of Science Notebooks. The workshops were facilitated by two science education lecturers from the Nelson Mandela Metropolitan University (NMMU) and two lecturers specializing in the Science Notebooks approach from University of North Carolina-Wilmington (UNCW). The baseline investigations suggested that a degree of scaffolding was required if the teachers were to successfully implement the process and, as such, the experimental group of teachers (n=3) and the research team cooperatively identified topics developed a lesson observation timetable together during the Science Notebooks workshop for their first of three classroom observations running over one school quarter. The topics chosen were based on the cohesive properties of water, properties of magnets and electric current (batteries and bulbs).

The teachers requested that the first classroom observations be conducted one week after the professional development workshops. Each science teacher was observed as they implemented the Science Notebooks approach in their classroom. Immediately following their classroom observation session, the teachers were interviewed using the same interview schedule that was used to generate the baseline data. After all of the initial experimental group classroom observation sessions were completed (this was done over a period of one week), the teachers met with the researchers as a group for a three-hour discussion session on their lessons. These teachers were able to share best practices and feedback was given by the researchers in terms of what had been observed in their classrooms and on possible strategies that could be used to improve their Science Notebooks approach. In an attempt to maximise the validity of the observations, discussion took place between the researcher and the educator with the explicit objective of reaching a mutual understanding of the meaning and context of the events that had taken place in the classroom (Schumacher & McMillan, 1993). This observation-interview discussion process with the experimental group of teachers occurred three times during the course of the Science Notebooks intervention.

Control Group

Teachers from the control group were also observed and interviewed three times after the initial baseline data collection process. The same topics and instruments, i.e., the interview schedule, the Science Inquiry Observation Scale and the Science Notebooks Checklist, were used for both the control and the experimental groups. However, no reciprocal processing session (discussions) of their teaching observations took place with the control group teachers, nor did they receive any feedback from the researcher in terms of what had been observed in their classrooms or further discuss ways of improving their teaching strategies.

Learners' Science Notebooks

Prior to the first classroom observations, the teachers from the experimental group introduced the concept of the Science Notebooks to their Grade 6 science classes. At each point of an investigation, the teachers instructed the learners to write down the various headings, i.e. date/ time, question, procedure, observation, conclusion and line of learning, which provided their learners with a writing frame. The learners used their Science Notebooks for three separate investigation entries. Following the initial investigation, five Notebooks from each class were randomly selected and analysed against the Science Notebooks Checklist. Throughout the intervention process we analysed the Science Notebooks of the same five learners per class across all three observations. The control group, however, produced no writing material for analysis.

Data Collection Instruments

The Science Inquiry Observation Scale and the Science Notebooks Checklist used in the study were developed and validated by researchers at the University of North Carolina - Wilmington (UNCW) and used in a number of Science Inquiry and Notebooks studies (Nesbit, Hargrove & Fox, 2003; Nesbit, Hargrove, Harrelson & Maxey, 2004; Reid-Griffin, Nesbit & Rogers, 2005). During each classroom observation session, there were two observers present to rate the lesson, during which each rater completed their observation scales individually. After the observation session, the raters compared their scores for consistency. Any inconsistencies were discussed and clarified and final scores were agreed upon “through discussion and consensus” (Nesbit, Hargrove & Fox, 2003: 8).

Although the instruments were developed for American schools, they were considered to be sufficiently general for use in our context. The interview protocols, however, were drawn up especially for this study and focused on context and classroom environment, as well as science writing and inquiry-based teaching.

Science Inquiry Observation Scale

This instrument is designed to measure the degree of inquiry-based teaching used by the teachers in their science lessons. The instrument assessed six areas in relation to the scientific process: constructing a testable question, designing the procedure, implementing the investigation, collecting data, making scientific drawings and drawing conclusions. The assessment is based on a four point scale with an additional assessment (level zero) to indicate the absence of that component. Levels one through four are based on a continuum of ‘telling’ to ‘guiding’, for instance assessment on ‘how well the teacher promotes learners’ independence in constructing an investigable question’ has five possible scores ranging through zero (there is no evidence of a testable question) to one (teacher states a testable question), to two (teacher guides learners towards a testable question but ultimately frames the question), to three (through questioning teacher leads learners to a testable question) to four (learners generate testable questions independent of teacher guidance).

Science Notebooks Checklist

The Science Notebooks Checklist instrument assessed the extent to which the work in the children’s Notebook reflected principles of scientific inquiry and investigations (Reid-Griffin, Nesbit & Rogers, 2005). This checklist was used to assess learners’ writings in order to determine the degree to which they were able to construct a testable question, devise, implement and write up their procedure, collect data, draw scientific illustrations, and draw conclusions (Nesbit, Hargrove & Fox, 2003). The components were assessed on a rating scale of 0 – 4, with an increase in score indicating increasing learner ownership and self-construction of knowledge (Nesbit, Hargrove & Fox, 2003). Rating level zero indicated that there was no evidence of the desired activity indicator; level one indicated that the learner had simply copied the teacher’s information; level two suggested that that the learner was able to generate his/her own information, but the information was inaccurate; level three indicated that the learner generated his/her own ideas, but that the information was incomplete or missing details. Finally, level four indicated that the learner had generated complete and accurate information.

Teacher Interviews

Upon completion of each classroom observation session, all teachers (experimental and control) participated in a semi-structured interview administered by the researcher. The interview served four objectives: 1) to determine if what had been observed was a typical science lesson and not a lesson taught in isolation for the purpose of the evaluation; 2) to determine the educator’s perception of their classroom environment; 3) to assess what writing activities were taking place in the classroom; and 4) to determine the educator’s perception of inquiry science. Probes were provided to assist the interviewer in getting as complete an answer as possible to all of the questions asked.

Limitations to the study

The small sample of schools means that the data generated cannot be generalized to the South African education context, nor can they say anything about the long-term effects, i.e. the extent to which teachers manage to keep up their changed practices after the intervention has stopped and time has passed (something perhaps which should be followed up on in another study). Nevertheless, the information gleaned from the small number of participants in this study can be used to raise issues and possibly initiate some debate in term of the possibilities of local use of the Science Notebooks approach (which is largely unknown and unused in the South African context). Also, as always, there is the possibility that the lessons presented in this study were not 'authentic' in the sense that the teacher prepared the lesson by rehearsing it with the learners in advance. There is also a prospect of the learners engaging in a previously delivered lesson. Despite these limitations, even practised and contrived use of the Science Notebooks approach does provide some insight into the feasibility and possibilities of using this approach in the types of classrooms in which this research took place.

Results and Discussion

In this section we present and discuss the results of the baseline data gathering exercise, the classroom observations of the control and experimental groups, and the data generated by inspection of the learners' written records.

Baseline data

Baseline classroom observations revealed that there were little to no inquiry teaching strategies implemented in the eight observed classrooms. The learners were not able to generate an investigable question, nor were they expected to do so. Half of the teachers did not display any evidence at all of being able to help their learners develop an experimental procedure and showed no evidence of understanding data collection techniques. The learning environments in these situations could not be described as inquisitive, participatory or focused on understanding the concepts. Instead, the lessons which the teachers presented were focused on mastery of content with little emphasis on the development of skills and the nurturing of inquiring attitudes (Baxter, Bass & Glaser, 2000; Maree & Fraser, 2004). Learners were not asked to make predictions in any of the eight baseline lessons observed nor were they expected to generate their own plan for the experimental procedure or the collection of data. The learners were also not required to make any scientific or technical drawings during any of the lessons.

During the baseline observations, five out of eight teachers did not provide any evidence that the learners understood the science concepts being taught. The other teachers discussed various science concepts but spent little or no time assessing learners' comprehension or understanding of the topics presented. Additionally, the three teachers who provided information simply relayed the information by writing down terms or ideas on the board, but their learners were not encouraged to actively construct meaning or communicate their ideas during the lesson. If the learners were asked any questions during the lesson or investigation, the questions were generally close-ended.

The majority of the teachers stated that the observed lesson was part of their lesson plans, but it appeared in most cases that the lesson had been taught in isolation of plans or work schedules. Although it was clearly stated to teachers and principals that the observation was not an inspection or a critique on their teaching, one teacher admitted presenting a duplicate lesson in an attempt to illustrate what he considered to be a successful investigation and one which his class enjoyed. One teacher commented, "I enjoy presenting my learners with information and giving then an activity relating to the information." This 'presentation' style was representative of other lessons observed. The teachers generally stood in front of their classes, presented the content of the lesson and then assigned each group a worksheet or activity to complete.

According to the teachers interviewed, the main cause of non-participation by their learners in the classroom is because of the learners' poor conceptual knowledge of science. Another common theme was that of the medium of instruction made it difficult to promote classroom discussion. One teacher commented that it was difficult for her to perform investigations if classrooms were not properly equipped with materials and apparatus. In terms of learner writing, the teachers interviewed noted that the writing activities that took place in their classrooms only included tests, examinations and completing worksheets. The teachers had difficulty in expressing an understanding of inquiry science and gave little indication of understanding the requirements of scientific investigations.

Classroom observations

The data generated through classroom observation after implementation of the Science Notebooks approach with the experimental group of teachers revealed an overall increase in aggregate scores for the three teachers who had participated in the Science Notebooks approach workshops over time (Figure 1). This general pattern of increasing scores was reflected in each individual teacher's case from the baseline observation until the third and final lesson.

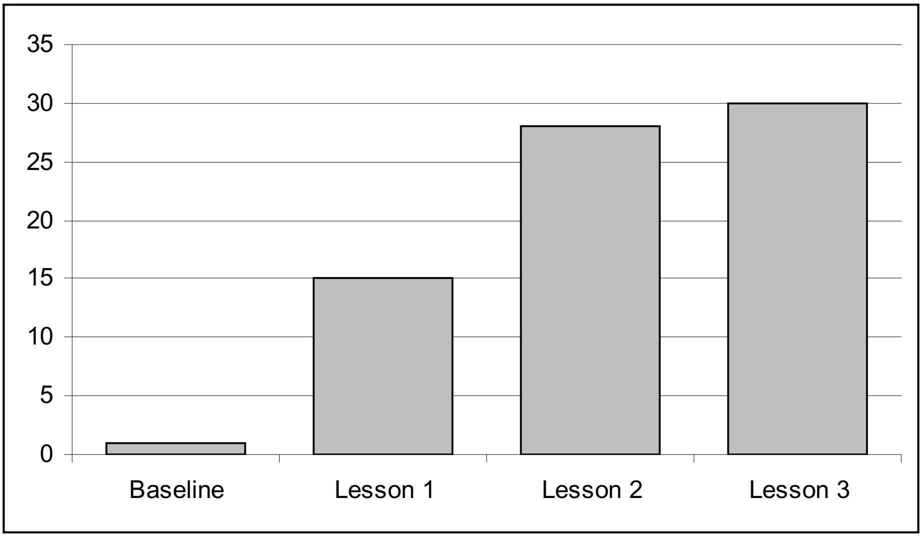
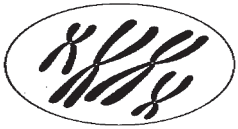


Figure 1: Aggregate Science Notebooks teacher implementation (classroom observation) scores over time for the three teachers who participated in the Science Notebooks approach workshops.

The improved performances noted in Figure 1 were, however, not equally evident across all categories in terms of magnitude, but were similar in terms of a trend towards improvement over time in almost all cases, as is shown in Figure 2 using the teachers' average scores on a five point scale.

Cell A

Cell B



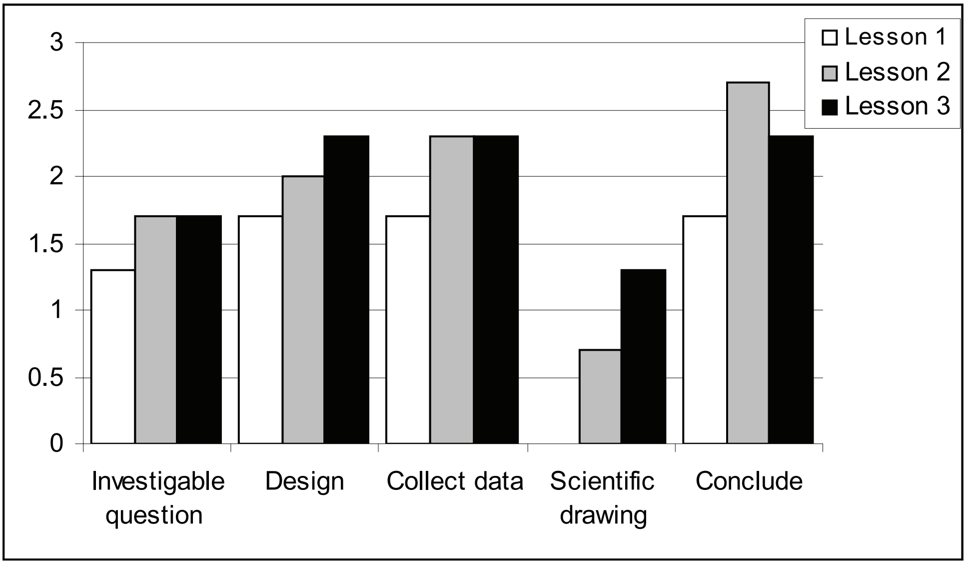


Figure 2: Average Science Notebooks teacher implementation scores per category assessed over time for the group of three teachers who participated in the Science Notebooks approach workshops.

Overall, the experimental group of teachers was observed to progress from not being able to generate meaningfully investigable questions during the baseline lessons observed, to all being able to lead their learners towards generating a testable question to some extent. An example of such a question generated by the learners with assistance from their teacher was "Can we make a light bulb light up using a wire, battery and a bulb?" Once the testable question was established, the data suggests that the teachers in the experimental group were also able to assist students in designing their procedure, collecting their data, and drawing conclusions. Although in all cases observed the teachers had to frame the final statement of the investigable question for their learners, the amount of input they had to make in terms of the other categories of the Science Notebooks process decreased over time. The teachers showed little inclination to get their learners to include scientific illustrations in their reports, but this aspect of the Science Notebooks approach did take place during the third investigation (electricity) observed and learner generated illustrations were recorded in their science notebooks (see figure 3).

Research on the Science Notebooks approach reveals that getting learners to ask meaningful questions that are testable or investigable is a common problem that educators face (Cheong, 2000; Heil, Amorose, Gurnee & Harrison, 1999). During interviews and feedback sessions, the teachers credited their progress in utilising Science Notebooks strategies to the professional development workshops and discussion during the feedback sessions. They said that they had opportunities during these workshops to hone their process skills, practice investigations and learn how Science Notebooks can be used as a tool to promote their inquiry-based teaching strategies.

During the same period, as would be expected, the control group displayed minimal to no change in their teaching practices from the baseline ratings through their three classroom observations. They continued with traditional methods of expository teaching, rote learning and the occasional observation type practical activity. Learners did not write notes, create scientific drawings or draw conclusions based on their observations or the teacher's lesson, despite that fact that all of these science teachers have been trained by the Department of Education on the learning outcomes and assessment standards for Scientific Investigations as described in the national curriculum statement (Department of Education, 2002).

Learner's Science Notebooks

The data generated on teachers' classroom practice are based on the observers' assessment of the ability of the participating teachers to carry out the activities and behaviours that are expected to enable children to be able to participate independently in scientific investigations. Whether these behaviours were translated in any way into learner achievement was investigated by examining their written records using the Science Notebooks Checklist.

Inspection of the sample of learners' Science Notebooks revealed that in all but one of the records examined the children had simply copied their teacher's investigable question and that there was no quantifiable improvement in this component of the Science Notebooks approach over time. There were quantifiable improvements in terms of the learner's ability to successfully implement the design, data collection, scientific drawings and conclusion aspects of the intervention. These improvements are illustrated in Figure 3 where the percentages of the entries per sample (n=45) of the learner Notebooks that were judged at levels three and four (i.e., satisfactory achievement) are plotted for each component being assessed. Level four scores indicate that the learners were able to generate their own information in a substantially complete and satisfactorily accurate manner while level three denotes that some details were missing and that the account was judged to be incomplete. These two levels have been combined in Figure 3 as they both denote levels of satisfactory performance.

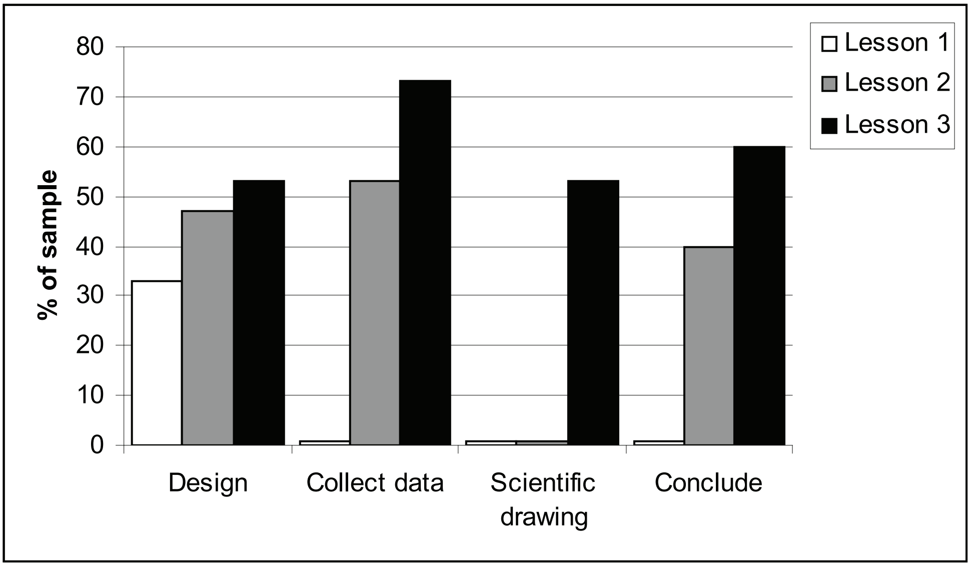


Figure 3: Percentage of entries (n=45) per component in the learner Notebooks that were judged to be at a satisfactory level of achievement (i.e., at levels three and four) for each of the three lessons.

Two-thirds (10) of the learners simply copied their teacher's design in the first lesson, while eight of the fifteen were able to write up their own procedural plan in the second and third lessons respectively. Initially the learners had difficulty in generating their own data, but this aspect of the process also improved over time. All of the learners simply copied their teacher's data into their Science Notebooks during the first lesson, but only seven had to be helped by the teacher during the second investigation. Eleven of the fourteen learners generated and recorded their own data at levels three and four during the third investigation.

The number of learners who used scientific drawings in their reports was initially very low and only in the final sessions did the learners appear to understand that this was a legitimate and valued way of reporting. All fifteen learners relied on their teachers to dictate a conclusion for their first investigation report. In the second Notebooks entry (magnetism) three learners managed to draw valid conclusions on their own and report them in their own words (level four), while three wrote up their conclusions in their own words in a manner that was judged to be incomplete or not satisfactorily accurate (level three). In the third and final investigation (electricity) the Notebooks entries revealed that six learners could draw valid conclusions on their own and give a written report in their own words (level four) and three were able to write an explanation in their own words but which were judged to be incomplete (level three). These data suggest that progress was made through practice by both the teachers and their learners while engaging in the Science Notebooks approach to carrying out scientific investigations (except for the process of generating investigable questions).

Conclusion

The baseline study suggests that it is more than likely that prior to the intervention learners were seldom, if ever, encouraged to ask questions or to communicate their thoughts in the classroom through either oral communication or formal science writing activities. This remained the case for the control groups of students. Even after three attempts at implementation, all of the experimental groups of learners remained dependent on their teachers for their investigable question, and many others for their procedures, data collection, drawings and conclusions. However, the problem of getting children to formulate their own investigable questions is one which has been shown to be a common problem internationally (Cheong, 2000; Heil, Amorose, Gurnee & Harrison, 1999). Also, it must be remembered that for many science teachers providing learners with the opportunity to pursue open-ended inquiry is usually not part of their current practice. As such, Ruiz-Primo, Li & Shavelson (2002) caution that Science Notebooks writing can be approached mechanistically, a process which results in ineffective implementation. It is therefore important that the support given to teachers should explicitly focus on how they can engage learners in the approach so that they *do* ask questions, describe objects and events, test their idea with what is known, and communicate what they are learning (Chiappetta, 1998), a shift in approach which probably requires a significant amount of support from educator development agencies (Edelson, 1997).

Campbell & Fulton, (2003) believe that by utilizing Science Notebooks for writing, discussing and reflecting exercises, learners begin to focus on the extent to which they understand the content. Hand, Wallace and Yang (2004) also point out that the act of focusing on content enables learners to make meaningful connections with their prior experience. This appears to be reflected in this study by improvements in some learners' abilities to draw conclusions and provide written reports in their own words. In terms of teachers, Baxter, Bass and Glaser (2000) warn that the viability of the Science Notebooks approach depends on how it is used by science teachers in their own teaching and learning environments. Many researchers argue that emulating and communicating authentic scientific investigations helps lead teachers away from the unsophisticated notion of science as a process in which learners simply gain knowledge and learn process skills towards a richer understanding of science, which includes scientific concepts, reasoning and critical thinking (Bybee, 1997; Fulton & Campbell, 2004; Miller & Calfee, 2004; Mintz & Calhoun, 2004; Ruiz-Primo, Li, & Shavelson, 2002). The limited data generated in this study, and the well documented success of the approach in western societies, appears to warrant further investigation of the applicability of the use of the Science Notebooks approach in our South African context. The viability of the approach may be particularly useful in the context of previously disadvantaged schools where our teachers often appear unable to communicate attitudes of curiosity, respect for evidence and critical reflection necessary for the development of higher-order cognitive skills (Taylor & Vinjevold, 1999).

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