THE NATURE AND IMPACT OF ACCREDITED IN-SERVICE EDUCATION ON UNDER-QUALIFIED SCIENCE AND MATHEMATICS TEACHERS: WHICH FACTORS GENERATE BEST PRACTICE IN THE CLASSROOM?

by

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SUMMARY

The problems surrounding Science and Mathematics Education contribute greatly to the current national crisis in education in South Africa. At present there are a large number of under-qualified teachers who lack the knowledge and skills to teach these subjects competently. This need underpinned the development of a course at the University of Port Elizabeth which provides both a thorough understanding of the concepts, and mastery of those methodological, language and classroom management skills which are fundamental to the successful teaching of Science and Mathematics.

Teachers registered for this in-service professional teacher education initiative are taught in Port Elizabeth, Queenstown and KingWitliam'sTown and comprise of teachers in a range of teaching situations, i.e. from urban to deep-rural farm school classrooms. This geographically diverse group provided the sample population for this study, viz. *'The nature and impact of accredited in-service education of under-qualified Science and Mathematics teachers: Which factors generate best practice in the classroom?'*

The specific purpose of the study was to investigate which factors in the teacher development process generate best practice in primary Science and Mathematics classrooms. This was done within a theoretical framework of INSET outcomes as described by Harland and Kinder (1997). Special areas of investigation were teachers' knowledge and understandings of Science and Mathematics as regards basic concepts and processes; pupil outcomes (i.e., what do pupils know and what can they do with their knowledge and understandings of Science and Mathematics); and which outcomes of the INSET process have enabled the teachers to be most effective in their classrooms.

It is clear that the teachers who have participated in this in-service professional teacher development initiative, i.e. the Diploma in Education focusing on Science and Mathematics Education (DE), for more than a year have significantly better understandings in Science and Mathematics than their peers who have not been exposed to this type of intervention. This has been translated into significantly better

pupil outcomes in these subjects in the classroom. Also, where difficulty is experienced with aspects of Science or Mathematics, misconceptions may be shared - sometimes by teachers, sometimes by pupils and, in some cases, by both pupils and teachers. Diagnosis of these shared misconceptions is potentially of great value in informing better practice, both for teachers when teaching their pupils and for the developers of INSET courses.

One of the first INSET outcomes to manifest itself in the classroom is the use of practical teaching aids by teachers in their teaching. Another is the physical re-arrangement of classrooms to allow pupils to sit in groups. It appears that the most difficult aspect of teaching to change is teachers' desire and ability to ask questions of their pupils and, in turn, to get their pupils to ask questions of them. It is suggested that this reluctance may be linked to teachers' lack of conceptual understanding of the topic being taught.

The INSET outcomes produced by the DE focusing on Science and Mathematics fit comfortably within Harland and Kinder's (1997) hierarchy of outcomes. There are clear indications that all of their third, second and first order outcomes were met to varying degrees by the DE course and that these outcomes had differing effects on teachers, despite the same intervention. It is also clear that the dominant outcomes generating `best practice' are the first order outcomes of improved knowledge and skills and a high degree of value congruence.

The classroom evaluations, interviews and testing of teachers and pupils support the notion that the impact of the above outcomes on change in classroom practice can be evaluated against a number of indicators. It appears important that the specific outcomes that could be expected from any particular teacher development programme need to be made explicit when developing the course. Only then can the intervention be expected to successfully generate 'best practice'. Without investigations into specific outcomes and their effects, teacher INSET is in danger of remaining at a level of generality that is insufficiently defined and precise to be of much assistance to policy makers, planners and practitioners.

Which factors generate best practice in the classroom?

1. INTRODUCTION

The problems surrounding Science and Mathematics Education contribute greatly to the current national crisis in education in South Africa. At present there are a large number of under-qualified teachers who lack the knowledge and skills to teach these subjects competently. Successful teaching of Science and Mathematics is further constrained in this country because teachers often lack proficiency in the most common medium of instruction, English. This problem is exacerbated by the fact that learning also takes place through the medium of a second language.

The above problems naturally apply to any other subject that must be taught, but it is universally accepted that the specifically conceptual nature of Science and Mathematics compounds the issue dramatically. Moreover, pre-service teacher education in these subjects in South Africa has frequently been of poor quality. For these reasons it is especially problematical for teachers to equip themselves to be adequate teachers of Science or Mathematics. This need underpinned the development of a course at the University of Port Elizabeth which provides both a thorough understanding of the concepts, and mastery of those methodological, language and classroom management skills which are fundamental to the successful teaching of Science and Mathematics.

This teacher upgrading initiative, viz. a Diploma in Education (DE) focusing on Science and Mathematics aimed at underqualified (M + 2) teachers, has attracted nearly 300 registrations in 1998 in urban and rural areas of the Eastern Cape. The 300 hours of contact time are shared equally between courses in Physical Science, Mathematics, Communication and Education. The diploma aims to simultaneously address:

* The urgent need to improve the position of teachers in the Eastern Cape who do not have 'matric + 3' qualifications, i.e. 12 years of schooling plus three years of professional training
* The need for teachers to become more competent in the critical fields of Science and Mathematics
* The problems inherent when teaching and learning take place through a second language

It should be borne in mind that this strategy is aimed at a subset of teachers in the Eastern Cape, i.e. those:

* with a minimum of three years' teaching experience
* who wish to be recognised as competent classroom specialists in Science and Mathematics
* who require to be accredited to a level equivalent to the current minimum requirement to be recognised as a qualified teacher

The measurement of teacher competencies forms an integral part of the curriculum, therefore assessment of classroom practice plays an important role in the learning and evaluation process. Teachers registered for this in-service professional teacher education initiative (DE focusing on Science and Mathematics) are taught in Port Elizabeth, Queenstown, KingWilliam'sTown and George. In this way the initiative involves teachers from a range of teaching situations, i.e. from urban to deep-rural farm school classrooms. This geographically diverse group provided the sample population for the research question raised in this study, viz. '*The nature and impact of accredited in-service education of under qualified Science and Mathematics teachers: Which factors generate best practice in the classroom?*'

The specific purpose of the study was to investigate which factors in the teacher development process generate best practice in primary Science and Mathematics classrooms. This was done within a theoretical framework of INSET outcomes as described by Harland and Kinder (1997). These authors' hierarchy of outcomes is described in the section below entitled 'Theoretical frame of reference'. Although cognisance is taken of Harland and Kinder's third-and second-order outcomes, particular reference is made to their first-order outcomes of value congruence and knowledge and skills, i.e. the INSET outcomes that they believe have the most impact on teacher practice.

Special areas of investigation were teachers' knowledge and understandings of Science and Mathematics as regards basic concepts and processes; pupil outcomes (i.e., what do pupils know and what can they do with their knowledge and understandings of Science and Mathematics); and which outcomes of the INSET process have enabled the teachers to be most effective in their classrooms.

2. THEORETICAL FRAME OF REFERENCE

Research into the impact of in-service continuing professional education for teachers, i.e. INSET (In-service Education and Training) or CPD (Continuing Professional Development), suggests that in-service activities have very varied influences on teachers and that different teachers nominate different outcomes as accruing from the same INSET provision. These differences suggest that INSET participants have a unique 'outcome route' following an in-service experience, and that they rarely achieve exactly the same permutation of outcomes as other colleagues (Harland and Kinder 1997).

Also, when teachers' accounts of the impact of INSET experience on their classroom repertoire are juxtaposed with classroom observation of their practice, it is apparent that certain outcomes are more likely to achieve concrete developments in the classroom than others. This observation, and the assumption that improved classroom practice is the ultimate intended INSET goal, prompted Harland and Kinder (1997) to develop a tentative sequence or hierarchy of outcomes (Figure 1).

INSET input			
3rd order	Provisionary	Information	New awareness
2nd order	Motivation	Affective	Institutional
1st order	Value congruence	Knowledge and skills	
Impact on practice			

Figure 1. An ordering of INSET outcomes (Harland and Kinder 1997).

When considering the possible *effects* of CPD on classroom practice, the outcomes which make up Harland and Kinder's (1997) typology (Figure 1), and the findings of other researchers in this field, provide a helpful framework. Firstly, research data suggest that *material and provisionary (third order) outcomes,* i.e. the physical resources which result from participation in INSET activities (worksheets, equipment, handbooks, etc.) can have a positive and substantial influence on teachers' classroom practice (Fullan and Stiegelbauer 1991). However, provisionary outcomes can be achieved without resulting in better classroom practice. Intermediary outcomes such as *motivation* and *new knowledge* are required to ensure that these outcomes impact on practice. On the other hand, successful classroom implementation of what is learned may be impeded by the absence of materials and physical resources (Harland and Kinder 1993).

Informational outcomes are defined as the state of being briefed or cognisant of background facts and news about curriculum and management developments, including their implication for practice. It is distinct from new knowledge and skills. *New awareness is* a perceptual or conceptual shift from previous assumptions which constitute the appropriate content and delivery of a particular curriculum area. For example, in primary science this may be a shift from teachers believing that science is about 'chemical equations and test-tubes' to feeling that it is about 'children investigating'. However, research corroborates teachers' own assertions that changed awareness is no guarantee of changed practice.

Affective outcomes acknowledge that there is an emotional experience inherent in any learning situation. Sometimes these experiences may be negative, leaving teachers demoralised by the INSET process. Initial positive affective outcomes may be short-lived if not accompanied by a sense of enhanced expertise. Nevertheless, these initial outcomes may be a useful, or even a necessary precursor for changing practice, working hand-in-hand with an increasing sense of competence in new knowledge and skills to produce a significant impact on practice (Schon 1971). *Motivational and attitudinal* outcomes refer to enhanced enthusiasm and motivation to implement the ideas received during INSET experiences, e.g. a teacher may feel inspired by what they see and attempt to emulate it. Like affective outcomes, these attitudinal outcomes are particularly important precursors for impacting on practice, but can also be short-lived or superficial if other outcomes - such as provisionary outcomes or new knowledge and skills - are not present (Harland and Kinder 1997).

INSET can also have an important collective impact on groups of teachers and their practice. The benefits of *institutional outcomes* such as consensus, shared meanings, collaboration and mutual support, when attempting curriculum innovation in the classroom, are fairly well established in the research literature (Harland and Kinder 1997).

Knowledge and skills outcomes denote the development of deeper levels of understanding, critical reflexivity and theoretical rationales, with regard to both curriculum content (e.g. enhanced understanding of scientific and mathematical concepts) and pedagogy (e.g. the management of investigations). Teachers often point to their lack of development in scientific knowledge and skills as a major obstacle to significant changes in their classroom practice. When knowledge and skills outcomes are not an INSET priority, few teachers report any appreciable advance in this respect (Eraut 1994).

Value congruence outcomes refer to the personalised versions of curriculum and classroom management which informs a practitioner's teaching, and how far these 'individuated codes of practice' come to coincide with the INSET providers' messages about 'best practice'. Value congruence with the INSET message is a crucial factor in influencing the extent of subsequent classroom implementation. This notion, i.e. Harland and Kinder's (1997) value congruence as a first order INSET outcome, approximates Fullan's (1993) key effects of the change process, i.e. "the alteration of beliefs, pedagogical approaches and theories underlying particular new policies or paradigms".

As noted earlier, the presence of certain outcomes is more likely to achieve developments in practice than others. Third-order outcomes are least likely to impact on practice, unless higher order outcomes are also achieved or already exist. In contrast, the presence of the two first-order INSET outcomes *consistently coincided with a substantial impact on practice* - however, these in turn may depend on the presence of other, lower order, outcomes, e.g. provisionary or institutional, to ensure sustained implementation (Harland and Kinder 1997).

While Joyce and Showers (1980) argue that a full suite of effects is necessary to bring about a change in a teacher's classroom practice, Harland and Kinder (1997) suggest that the achievement of all nine outcomes are not always a necessary condition for impact on practice. However, they agree that it was generally the case that the larger the number of outcomes met - either as pre-existing conditions or effects of CPD activities - the greater the probability of change in teaching behaviour.

Harland and Kinder's (1997) research also indicated no regular pattern of linear progression through the nine outcomes (or even a subset of them). The most evidence would allow was a ranking of the INSET effects into the hierarchy shown in figure 1. Rather than any linear progression, knock-on effects from one outcome to another could include advancement down the hierarchy as well as up, e.g. the learning of new knowledge and skills could trigger revitalised motivational and attitudinal outcomes. Far from being a uniform progression through the outcome-types, Harland and Kinder's (1997) case study teachers displayed a wide diversity of individualistic routes through the various categories of CPD effects. This was a very conspicuous finding, despite the CPD input being fairly standard. This highlights the case for identifying needs and designing INSET experiences from an individual's learning perspective rather than global prescriptions (Day 1993). It also underlines the need for regular evaluation and appraisal to monitor a teacher's progress along an unfolding, and personal, outcomes route.

The impact of the outcomes described above on change in classroom practice may be evaluated against a number of indicators such as the frequency and amount of Science and Mathematics tuition being undertaken by teachers; the intentionality and planning underpinning the Science and Mathematics activities provided for pupils; the organisation and management of these activities in the classroom; the nature of the interactions between teachers and pupils; the nature of the knowledge and skills of teachers, the achievements of pupils in Science and Mathematics; etc.

While recognising that singling out the outcomes (or effects of in-service provision and activity) side of a general theory of effective INSET may encourage mechanistic input-output perspectives on Continuing Professional Development (CPD), Harland and Kinder (1997) believe that, as most of the research conducted to date has tended to dwell on the processes of change and in-service activity (Hall and Oldroyd 1988, McBride 1989, Webb 1989, Galloway 1989, Harland 1990, Harland and Kinder 1992, Day 1993, Harland et al. 1993, Bolam 1994, Eraut 1994, Law and Glover 1995, McMahon and Ballard 1995, Steadman et al. 1995), it is appropriate at this juncture to pay more attention to the ways we conceptualise the outcomes of teacher CPD. This approach appears to be sensible when researching which factors of INSET generate best practice in the classroom, i.e. the focus of this study.

3. RESEARCH DESIGN AND METHODS

The research methodology used in this study combines both quantitative and qualitative strategies. Quantitative strategies include pre- and post-tests to assess the level of, and changes in, conceptual knowledge in both teachers and pupils. Tests (attachments 2 - 7) were drawn up to gather data on skills and understandings of scientific and mathematical concepts in the areas of fractions, electricity and measurement. The questions asked in the tests were based on misconceptions identified in international literature, the syllabus followed in South African schools, and the past experiences of the researchers when working with teachers and pupils.

The same tests were administered to both teachers and pupils. The post-test was longer than the pre-test to enable further 'teasing out' of concepts that the participants may have found difficult. However, for the purposes of this study, only the questions found in both the pre-test and the post-test were used for statistical analyses, i.e. all the questions asked in the pre-tests and the corresponding (identical) questions in the post-tests.

The qualitative and semi-quantitative strategies used in this study included the use of classroom observation schedules (attachments 8 and 9), questionnaires (attachment 10) and semi-structured interviews (see 3.4 below). The classroom observation schedules were used to determine the methods used by the teachers, the skills they employed, how they used materials, and learning outcomes exhibited by their pupils, i.e. to determine which INSET outcomes, if any, were evident from the teachers' classroom activities and environment. Non-parametric statistical analyses were applied to establish whether there was any correlation between certain classroom outcomes,. quality of teacher questioning and their ability to elicit questions from their pupils, versus teacher knowledge in the topic they were teaching.

The questionnaire was used to determine teacher perception of the course and what it espoused, i.e. an initial attempt at determining a measure of 'value congruency'. The rationale underpinning the semi-structured interview is dealt with under point 3.4 below.

3.1. Teachers' knowledge

Data on teachers' knowledge and understandings of Science and Mathematics concepts were collected by testing all teachers participating in the Diploma in Education: Primary Phase (focusing on Science and Mathematics) course (DE). The focus areas were fractions, electricity and measurement. These tests were trialled in 1997 as part of an informal evaluation of teacher and pupil knowledge. Separate tests were administered for each of these topics (attachments 2 - 7). The first-year students (teachers) wrote these tests early in the year and, as such, had not been exposed to DE coursework tuition on these topics before being tested. These samples of teachers, i. e. for fractions (n = 71), electricity (n = 65) and measurement (n = 97) were therefore considered to represent teachers prior to the 'treatment' (the DE course).

The second-year students had been exposed to DE tuition on fractions (n = 49) and electricity (n = 55) during their first year of study and, as such, were considered to be the 'post-treatment' sample. However, the second-year students had not been exposed to DE tuition on measurement and therefore this sample group (n = 49) yielded both pre-test (prior to DE tuition) and post-test (after DE tuition) data in this topic.

All tests were uniquely coded and the data subjected to statistical analysis. The treatment yielded general descriptive characteristics of the data, frequency tables, and analysis of variance (ANOVA) tables with tail probabilities using F test statistics as well as Welch, Brown-Forsythe and Levene's test statistics for variances.

3.2. Pupil outcomes

Data on pupil outcomes were gathered by testing the pupils of the sample of teachers who had volunteered to participate in the classroom evaluation component of this study (n = 37, viz 19 DE1 teachers and 18 DE2 teachers). Again the focus areas were fractions, electricity and measurement. Separate tests were administered for each of these topics. These tests were identical to the tests written by the teachers (attachments 2 - 7). However, all members of the pupil sample wrote both pre- and post-tests, i.e. prior to being exposed to tuition on the topic by their teacher (pre-test) and after receiving tuition on the topic by their teacher (post-test).

A total of 549 pupils comprised the sample group tested on fractions, viz. 376 pupils of fast year teachers (DE1) and 173 pupils taught by second year (DE2) teachers. The size of the sample group tested on concepts in electricity was 400, with 172 being pupils of first year DE teachers and 228 pupils being taught by second year teachers on the course. The testing of pupils' abilities as regards measurement was the only quantitative piece of this research where the sizes of the pre- and post-test groups differed significantly in number, viz the DE1 pre- and post-test groups consisted of 340 and 101 pupils respectively, while the DE2 pre- and post-test groups consisted of 146 and 73 pupils respectively.

As mentioned above, all test answer sheets were uniquely coded, with pupils being linked to their teachers, and the data subjected to BMDP statistical analysis. The treatment yielded general descriptive data, frequency tables, and analysis of variance (ANOVA) tables with tail probabilities using F test statistics as well as Welch, Brown-Forsythe and Levene's test statistics for variances.

3.3. The concepts tested

The questions asked on fractions at grade 5 level were designed to test a number of concepts. Firstly, question 1 tested the participants' understanding of quarters and their summative properties. Question 2 tested the participants' abilities to work in tenths while question 3 tested understandings of whole numbers and their equivalence to any numerator and denominator of the same magnitude, and the importance of this to be able to subtract fractions. Question 4 extended this theme using addition while question 5 tested the participants' understanding of the term 'doubling'. Question 6 tested the comprehension of the number of halves in a whole with an extension to numbers greater than 1. Question 7 involved pattern recognition while question 8 tested understandings of what is denoted by the magnitude of denominators when the numerators are equivalent. Question 9 is similar to question 6, using less familiar numbers.

Question 10 of the fractions paper tests the meaning of multiplying by a half, while question 11 tests the ability to use fractions in a 'real-life' problem-solving milieu. Questions 12 to 14, plus question 16, test spatial identification of fractions while question 15 relates fractions to divisions on a number line. Questions 17 and 18 test the ability to determine equivalence to relate the magnitude of fractions to one another, while questions 19 and 20 test the participants' understanding of the place value of decimal fractions.

The question paper on electricity tested understandings of both static and current electricity at grade 6 level. Question 1 tested participants' conceptions of what determines an object's charge while question 2 tests understandings of charge distribution, the mobility of charges and the notion of attraction. Questions 3, 4 and 5 probe the idea of objects being charged and uncharged and their interaction in terms of attraction and repulsion. Question 6 tests concepts of the nature of matter in terms of charges and how objects are charged (e.g., lightning). Question 7 tests understandings of circuits while question 8 specifically tests the understanding of the necessity of appliances, such as a light bulb, to be an integral part of a closed circuit for it to be able to function. Question 9 probes understandings of electrical circuits a little further.

The test on measurement at grade 7 level firstly tests the ability of the participants to read scales. A number of different scale units and instruments are used in questions 1 to 5, and question 8. Question 6 practically tests the participants' ability to use a ruler accurately. Question 7 tests the notion of displacement. Questions 9 and 10 test the ability of the participants to convert units while questions 11 to 14 test the pupils' and teachers' understandings of the dimensions required to calculate area as well as their relationships. Questions 15 to 18 focus on the concept of volume, i.e., dimensions and their relationships, the notion of faces (areas) of regular three-dimensional objects, and the division of three dimensional objects into regular cubic units.

3.4. Classroom observation

The qualitative strategies used in the research included the use of structured observation schedules to monitor what teachers do in the classroom (Cangelosi 1991). These were used to determine the methods used by the teachers, the skills they employed, and how they used materials, i.e. which INSET outcomes, if any, were evident from the teachers' classroom activities and the classroom environment. Learning outcomes exhibited by their pupils were also determined.

A sample of DE1 (n = 10) and DE2 (n = 10) teachers were observed in their classrooms for research purposes and some members of this group participated in semi-structured interviews. The schedule used for these observations was the same as was used, and reported on, in Rosalind Ntshinga-Khosa's 1997 publication on the evaluation of the Primary Science Programme (attachment 9). These lessons were video recorded to enable post-session reviews.

The classroom observation instrument (appendix 9) is made up of components related to effective teaching and learning in a learner-centred environment. These components are in line with the intended outcomes of the DE course and are in accord with research findings over the last decade (Ellet, Loup and Chauvin 1991, Heneveld 1994, Lockheed and Verspoor 1994)

When completing the schedule, the field researcher observed an entire lesson (30 minutes minimum) and sat in a location in the classroom where she could see the pupils in order to make inferences as to their engagement, observe interactions, etc. The fast component of the schedule, i.e. *use of a variety of teaching methods,* focuses on teacher strategies to involve learners and enhance learning. Traditionally South African teachers rely on 'chalk and talk' methods to dispense information to passive pupils. The DE methodology, however, requires pupils to take a more active role and emphasises a wide range of methods other than lecturing or writing on the chalkboard in order to enhance pupil learning.

The *'use of materials by learners'* component focuses specifically on the degree to which pupils have an opportunity to manipulate learning materials. The DE course promotes the use of apparatus and manipulatives to stimulate active involvement and promote learning. The 'use of materials by the teacher' component monitors the effective use of the chalkboard, posters, pictures, textbooks, etc.

The 'grouping of learners' component focuses on how the teacher organises pupils in the classroom. Traditionally teachers teach to the entire class at once as a group. The position taken in the DE course is that the potential for pupil participation and active involvement in learning increases when teachers place them small groups, and that the assignment of clearly defined roles in the group encourages pupils to take responsibility for successful completion of the task. Simply placing pupils in groups does not mean that these outcomes will be achieved. The fifth component, i.e. 'learners work in groups' section, focuses on what the pupils actually do when they are put in groups. Do they continue to work as individuals on assigned tasks or do they discuss questions, solve problems and be creative together?

The 'critical and creative thinking' component examines whether learning tasks stimulate the development of thinking skills. The DE methodology promotes the development of thinking skills by making explicit the notion that teachers must involve pupils in discussion and problem-solving.

Traditionally South African teachers often rely on close-ended questions with one right answer, or which simply require pupils to recall information, when teaching. The 'questioning skills' component of the schedule investigates whether the teacher can capture and focus the pupils' attention on critical parts of the subject matter and arouse their curiosity. The use of a variety of types of questions, including open-ended questions that have more than one answer and which allow teachers to probe learners' understanding, are promoted in the DE course. Also, encouraging learners' questions and contributions sends a positive message that pupils are an important part of the learning environment. Traditionally, however, in some African cultures, questioning of the teacher is a sign of disrespect. Therefore, DE teachers are encouraged to create a learning environment in which their pupils feel safe and feel free to ask questions.

A key element in guiding and enhancing learning is the provision of feedback to learners about their performance and mastery of learning objectives. Effective feedback strategies include suggestions for improving performance and encouragement of effort.Component 9 of the schedule, i.e. *`teacher feedback to learners',* investigates this intended outcome of the DE course.

Finally, the *`use of language to improve learner understanding'* component assesses the teacher's sensitivity to the difficulties experienced by pupils when learning in a second language. The DE teachers are mostly Xhosa mother-tongue speakers and are encouraged to integrate home language instruction into their teaching strategy, when appropriate, in order to promote conceptual development.

All of the DE2 students (n = 71) were also observed teaching twice in their classrooms using the standard evaluation form for the course (attachment 8). These data were also used to determine a conceptual framework of what is happening in DE classrooms in general.

3.5 Interviews

The research interviews, using a semi-structured format, took place after the teacher had been observed in action in his/her classroom. Initial questions related to the lesson observed. Follow-up questions were used when necessary to probe the information provided by the teacher. The interviews were audio-taped to allow post-interview reviews.

The interview schedule is as follows (the comments in italics reflect the reason for the questions):

Did you teach this topic in the same way as you did before you started the DE course?

To find out if the teacher is aware of the change in her/his teaching style.

What do you see as the key concepts and skills that you intended the learner to gain from this lesson?

Has the way in which you taught this lesson been influenced by the DE course - if yes, which part of the course influenced your teaching and planning?

The DE course is made up of 4 modules so need to know which modules have the most influence.

How has the course influenced your teaching? Have you tried this method before or is this the first time that you have tried these teaching strategies?

Need to know if this is now a more established strategy or still experimental.

How has your class responded to the teaching strategies that you used today? (Assuming that this is not the first time that the strategy has been used).

Is the teacher still focused on what she is doing in the classroom or is she able to take note of the class reaction? What evidence has she used to substantiate her responses - are they trivial or thoughtful?

If groupwork used - how often have you used groupwork with the class? How does groupwork influence the planning of lessons? Do you find it takes more time to plan the lessons? Why did you decide to use groupwork for this topic? How do you expect learners to benefit from this approach?

Similar questions would be asked if apparatus and other resources are used in an activity based lesson. How often do you use apparatus/resources in your teaching? What apparatus/resources do you have available in your school? Is it difficult to obtain the necessary resources? In what way do you think the use of the resources will enhance pupil learning?

It is important to determine if the teaching is simply copying the teaching strategy experienced in the DE course or whether the teacher has thought about pupil learning.

How do you believe learners acquire knowledge in Mathematics and Science? What evidence do you have of their learning?

Where did you do your initial teacher education course?

How long have you been teaching altogether and how long have you taught at this school?

How long have you been teaching either Mathematics or Science or both?

A number of teachers on the course do not teach Science or Mathematics on a regular basis, especially the Foundation Phase teachers.

Are there any other teachers at this school also doing the DE course?

This information should provide background information against which the expectations of the course can be assessed.

What approach to teaching was presented in your initial teacher education course?

What was your understanding of what a `good' teacher is supposed to be? Can you identify teachers that you had as being models of `good' teachers? Have you tried to be like those teachers?

What approach to teaching is presented by the DE course and how is it the same or different from that presented in your initial teacher education?

It is important to know what view of `good' teaching is held by the teachers and whether that view is being challenged by the DE course.

Has the DE course changed your view of what a 'good' teacher is? What characteristics do you now think are important for a `good' teacher and how do you think they can be achieved?

The cultural view of the role of the teacher is likely to be quite deeply embedded and there is likely to be tension between meeting the community expectations of an effective teacher and that of the course. The expectations of a rural community may be different from the expectations of an urban community and there may not be a common understanding of a 'good' teacher and 'best practice'.

The data obtained during this process was interpreted in conjunction with the conditions under which the teacher has to operate, viz. school facilities, resources, class size, remoteness of school, etc.

3.6 Questionnaire

Teachers (n = 123) also completed a questionnaire (attachment 10) based on an article in the Mail and Guardian giving guide-lines for choosing courses offered by the current plethora of service providers (attachment 11). The questionnaire was used to determine teacher perceptions of the course.

3.7 Fieldwork

The fieldwork was undertaken in the Queenstown, KingWilliam'sTown and Port Elizabeth areas of the Eastern Cape, South Africa. Seventeen DE1 teachers and 7 DE2 teachers from the Queenstown centre, two DEl teachers and 5 DE2 teachers from the Port Elizabeth centre, and six DE2 teachers from the KingWilliam'sTown centre took part in the classroom testing aspect specifically aimed at providing data for the research study (attachment 1). The pupils of these teachers comprised the pupil samples for testing. The DE2 (n = 71) teachers who were observed in their classrooms as part of the course requirements were distributed as follows - 20 in Port Elizabeth, 19 in KingWilliam'sTown and 32 in Queenstown.

The fieldworkers (associate researchers) were part of the process of developing the research strategy and instruments. They were also responsible for drawing up the teacher and student tests, as well as helping choose the classroom observation instruments. Initial classroom observations were made by pairs of fieldworkers in an attempt to standardise the evaluation process.

The only major retarding influence experienced was the threat of, and reality of, SADTU sponsored teacher strikes. The strikes in June affected a set of planned visits and delayed the time-frame of the research project considerably. Otherwise, the participating teachers were most obliging. Initially, the DE1 teachers showed some reluctance to volunteer to be visited in their classroom for research purposes. However this attitude changed after the first volunteers reported on their experience of the process. In contrast, the DE2 teachers clamoured to be observed in their classrooms, but appropriate (in terms of grade levels and subject taught) selections had to be made for the purposes of this research.

3.8 Formulation

The quantitative and qualitative data elicited via the methods described above were analysed and synthesised in an attempt to answer the research question, i.e. *Which factors generate best practice in the classroom?* The response to this question was formulated within a theoretical framework embracing Harland and Kinder's 1997 hierarchy of INSET outcomes. The research focused on teachers' knowledge and understanding of Science and Mathematics as regards basic concepts, classroom strategies and pupil outcomes, i.e., what do they know and what can they do with their knowledge and understandings of Science and Mathematics.

4. RESULTS

The data from the tests on fractions, electricity and measurement revealed the following.

4.1 Fractions

The mean scores attained by teachers and pupils in the fractions pre- and post-tests are illustrated in table 1 below.

	DE1 (T)	DE1 (P)	DE2 (T)	DE2 (P)
Pre-test	67%	14%	-	26%
Post-test	-	31%	85%	43%

Table 1: Comparison of teacher and pupil mean scores in the fractions test expressed as a percentage (T = Teachers; P = Pupils).

The DE1 teacher class average was 66.8% and the DE2 class average 84.7%. The lowest score, attained by a DE1 teacher, was 10%. A total of 21 teachers scored full marks for the test. Of these, 16 were DE2 teachers, i.e. 33% of the DE2 group, and 5 were DE1 teachers, i.e. 7% of the DE1 group. A comparison of the number of questions answered correctly by DE1 and DE2 teachers is illustrated graphically in figure 2, and numerically in table 2. Analysis of variance (ANOVA) showed a statistically significant difference (Table 3) between the DE1 (n = 71) and DE2 (n = 49) teachers' ability to work with fractions (F = 33.71, p = 0.0000).

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F VALUE	TAIL PROBABILITY
1-2 year	370.0298	1	370.0298	33.71	0.0000
Error	1295.2952	118	10.9771		
Equality of means test; variances are not assumed to be equal					
Welch		1,116		36.99	0.0000
Brown-Forsythe		1,116		36.99	0.0000
Levene's test for variances		1,118		5.42	0.0216

Table 3: Analysis of variance table for teacher mean scores in the fractions test.

The DE1 teachers' pupils (n = 376) scored an average of 14% and the DE2 teachers' pupils (n = 173) scored an average of 26% on the pre-test, and an average of 31 % and 43% respectively on the post-test.

A total of 154 pupils (28%) scored 10% or less for the test. However, only 5% of the DE2 pupils fell in this category. Full-marks were only scored by one pupil, a DE2 candidate writing the post-test. Both pupils and teachers had difficulty (i.e., less than 60% of the sample group answered the question correctly) with questions number 3, 15 and 20. A comparison of the number of teachers and pupils (post-test) correctly answering each question is shown graphically in figure. 3

A comparison of the number of questions answered correctly by DEl and DE2 pupils in the fractions pre- and post-test is illustrated graphically in figure 4, and numerically in table 4.

The data on pupil scores reveals a statistically significant difference (Table 5) between the DE1 and DE2 pupils' ability to work with fractions (F = 66.84, p = 0.0000). There was a statistically significant difference between these groups pre-and post-test scores (F = 126.06, p = 0.0000). The interaction error was insignificant (F = 0.00, p = 0.9525).

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F VALUE	TAIL PROBABILITY
1-2 year	677.7297	1	677.7297	66.84	0.0000
Pre-Post	1278.2801	1	1278.2801	126.06	0.0000
INTERACTION	0.0359	1	0.0359	0.00	0.9525
ERROR	5526.2326	545	10.1399		
Analysis of variance; variance are not assumed to be equal					
Welch		3,201		7764	0.0000
Brown-Forsythe					
1-2 Year		1,200		49.30	0.0000
Pre-Post		1,200		93.37	0.0000
INTERACTION		1,200		0.01	0.9300
Levene's test for variances					
1-2 Year		1,545		40.82	0.0000
Pre-Post		1,545		57.33	0.0000
INTERACTION		1,545		1.59	0.2070

Table 5: Analysis of variance table for pupil mean scores in the fractions test.

overall, teachers scored better in the grade 5 fractions test than their pupils (Figure 4).

4.2 Electricity

The mean scores attained by teachers and pupils in the electricity pre- and post-tests are illustrated in table 6 below.

	DE1 (T)	DE1 (P)	DE2 (T)	DE2 (P)
Pre-test	37%	34%	-	33%
Post-test	-	41%	65%	63%

Table 6: Comparison of teacher and pupil mean scores in the electricity test expressed as a percentage (T = Teachers; P = Pupils).

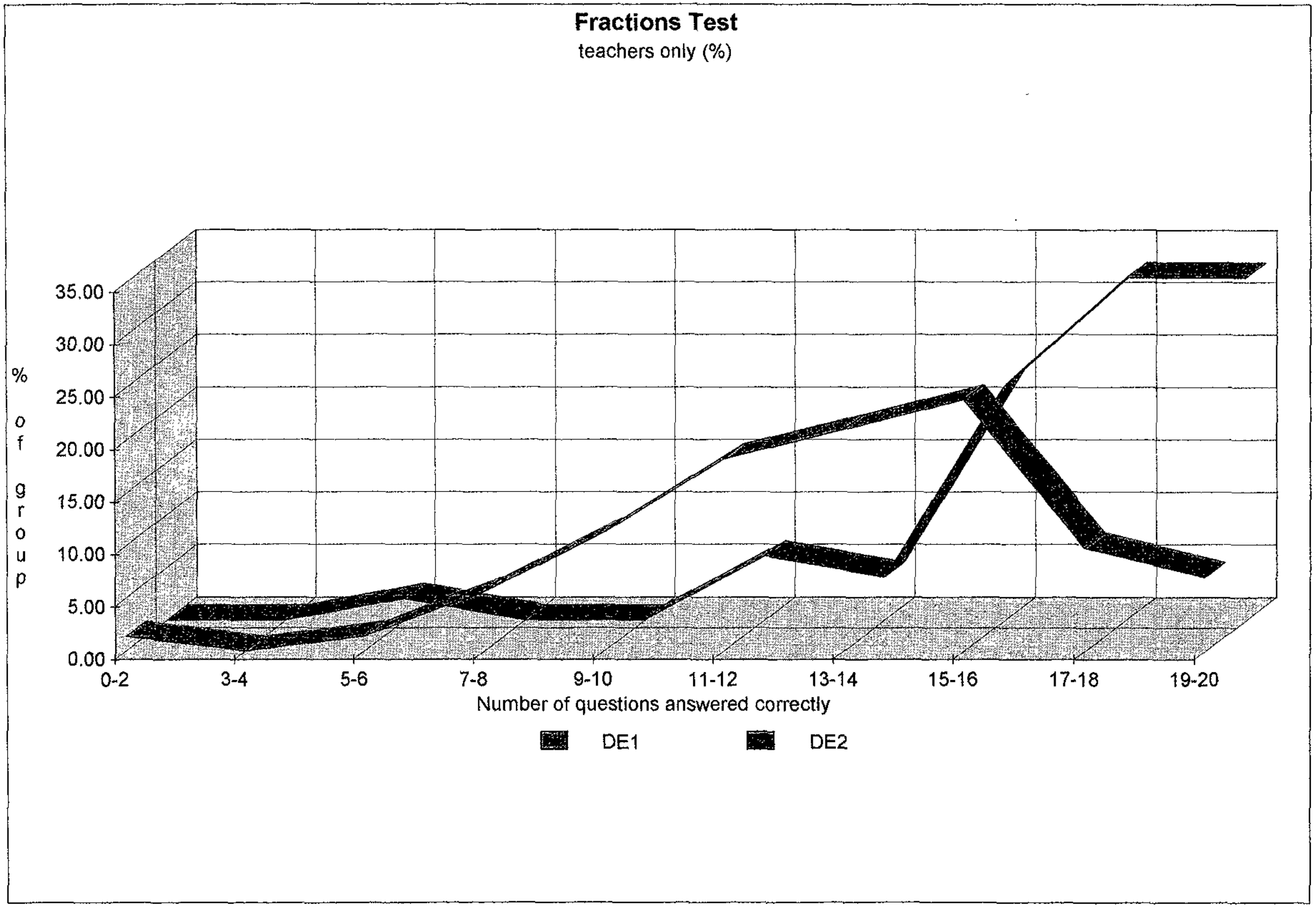


Figure 2: Comparison of DE1 and DE2 teacher scores in the Fractions Test

Teachers - Number of Correct Answers										
	0-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	19-20	
DE1	1	0	1	4	8	13	15	17	7	5	71
DE2	0	0	1	0	0	3	2	11	16	16	49

Teachers - Number of Correct Answers (%)											
	0-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	19-20	Total
DE1	1.41	0.00	1.41	5.63	11.27	18.31	21.13	23.94	9.86	7.04	100
DE2	0.00	0.00	2.04	0.00	0.00	6.12	4.08	22.45	32.65	32.65	100

Table 2: Number of Teachers per Score in the Fractions Test

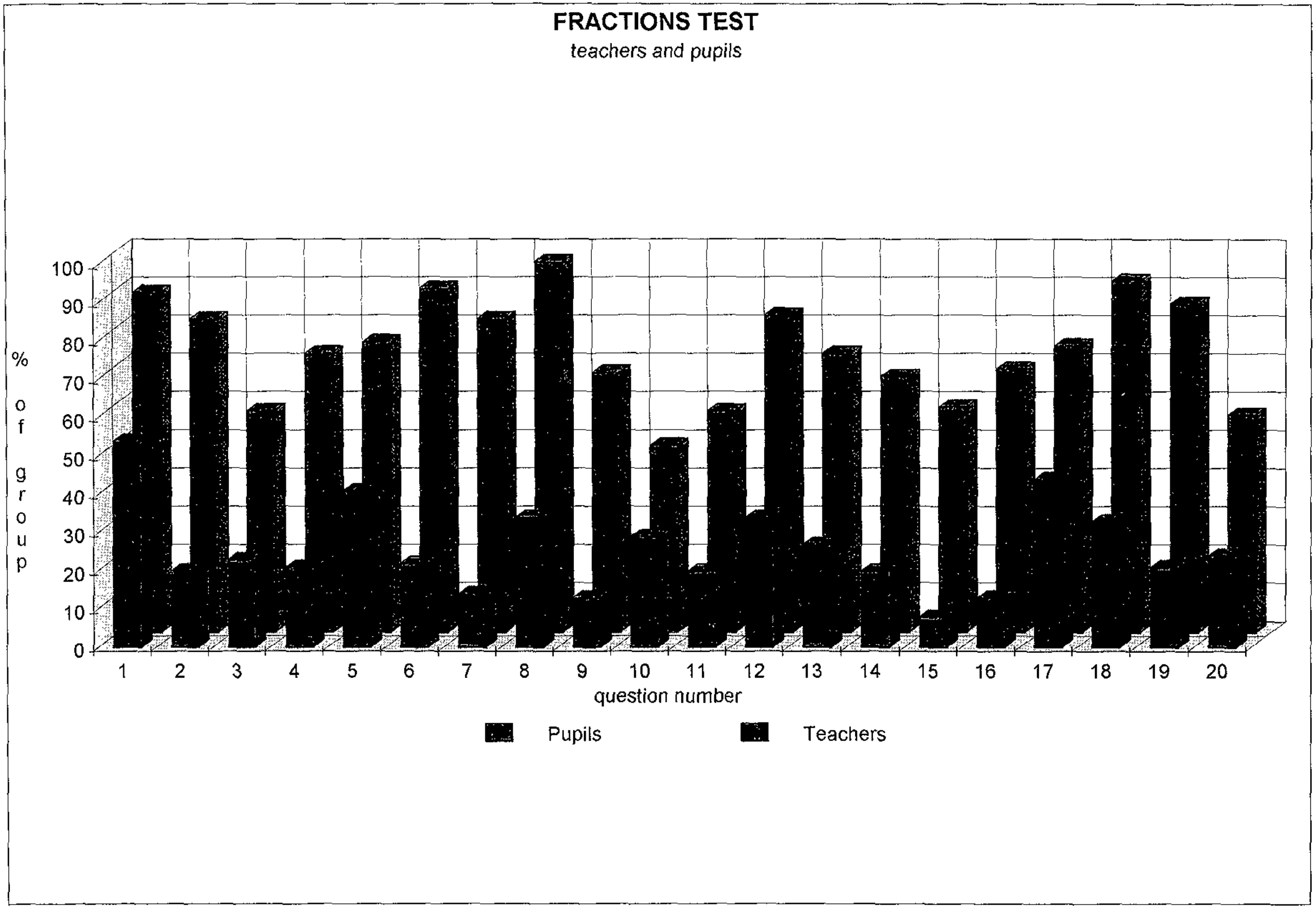


Figure 3: Comparison of number of teachers and pupils responding correctly to each question in the fractions test (expressed as percentage)

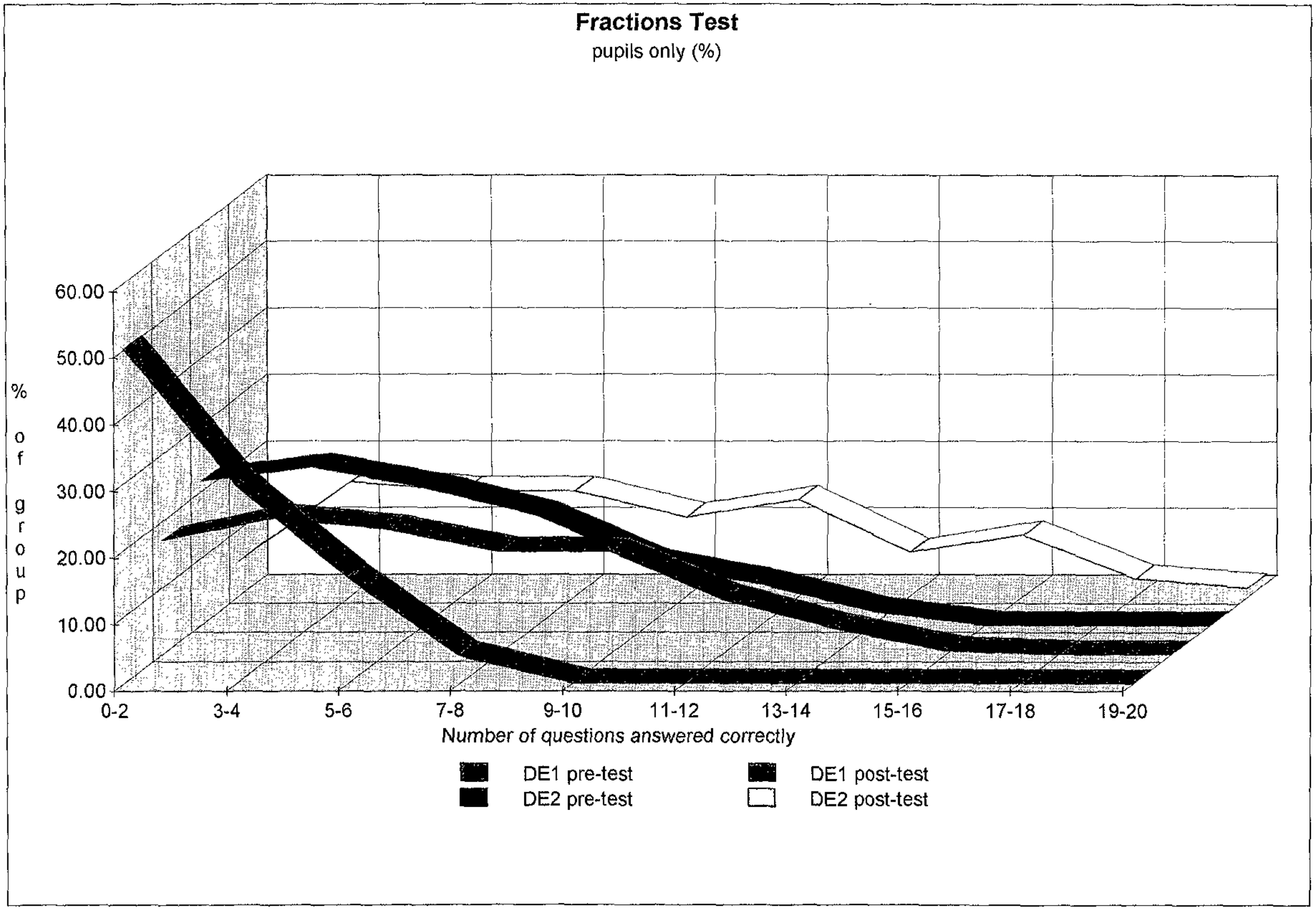


Figure 4: Comparison of DE1 & DE2 pupil scores in the fractions pre- and post- tests

Pupils - Number of Correct Answers

	0-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	19-20	Total
DE1 pre-test	98	58	31	8	0	0	0	0	0	0	195
DE1 post-test	31	37	34	28	28	15	7	1	0	0	181
DE2 pre-test	21	23	20	16	9	6	2	0	0	0	97
DE2 post-test	4	13	12	12	9	11	5	7	2	1	76

Pupils - Number of Correct Answers (%)

	0-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	19-20	Total
DE1 pre-test	50.26	29.74	15.90	4.10	0.00	0.00	0.00	0.00	0.00	0.00	100
DE1 post-test	17.13	20.44	18.78	15.47	15.47	8.29	3.87	0.55	0.00	0.00	100
DE2 pre-test	21.65	23.71	20.62	16.49	9.28	6.19	2.06	0.00	0.00	0.00	100
DE2 post-test	5.26	17.11	15.79	15.79	11.84	14.47	6.58	9.21	2.63	1.32	100

Table 4: Number of Pupils per Score in the Fractions Test

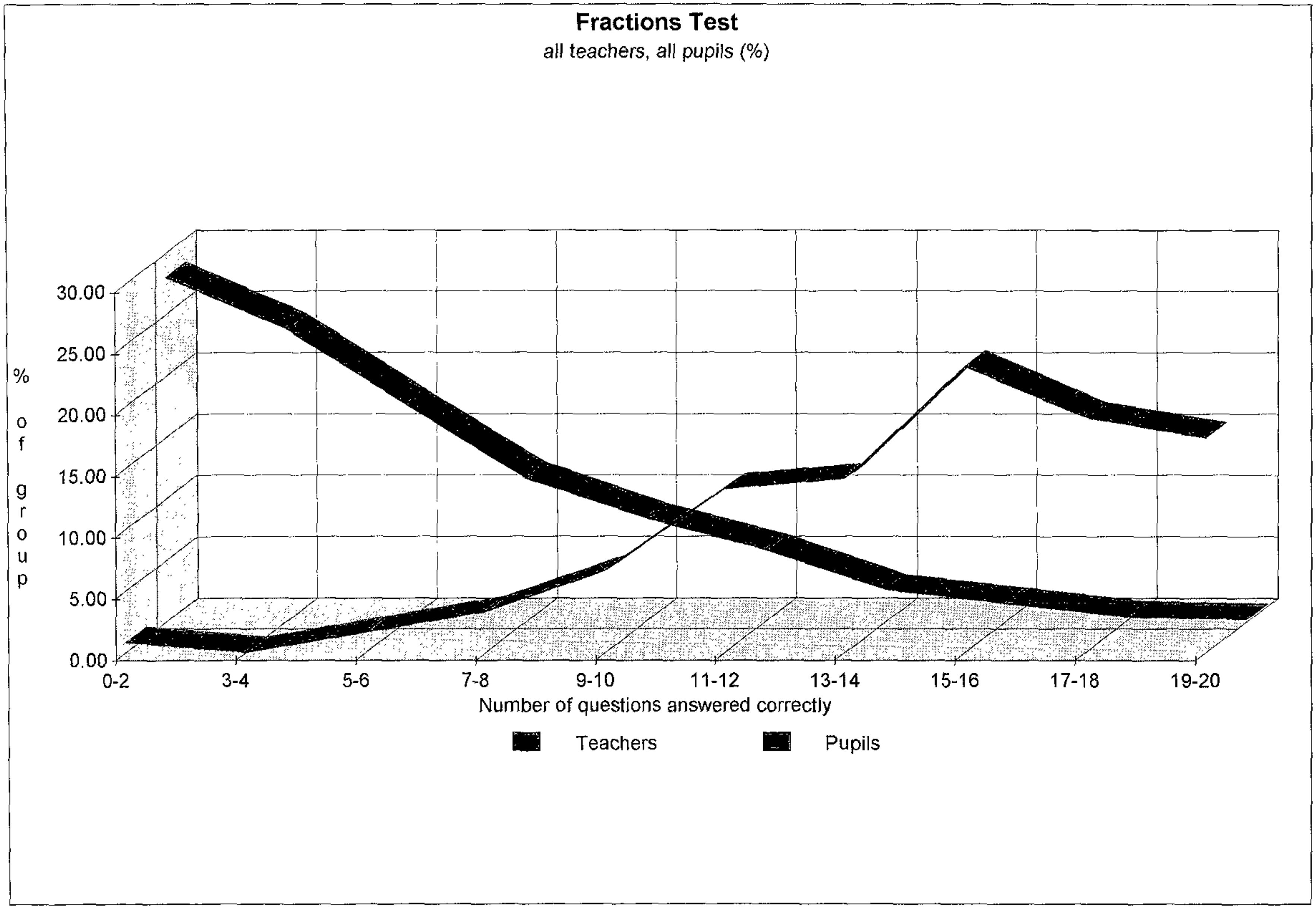


Figure 5: Comparison of teacher and pupil scores in the Fractions Test

The DE1 class average was 37% while the DE2 class average was 65%. Eight teachers (7% of the sample) gave only two or less correct answers while only 5% of the group scored 80% or higher. A comparison of the number of questions answered correctly by DE1 and DE2 teachers is illustrated graphically in figure 6, and numerically in table 7. There was a statistically significant difference (Table 8) between the DE1 (n = 65) and DE2 (n = 55) teachers' understandings of concepts in electricity (F = 77.38, p = 0.0000).

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F VALUE	TAIL PROBABILITY
1-2 year ERROR	324.2938 494.4979	1 118	324.2938 4.1907	77,38	0.0000
Equality of means tests; variances are not assumed to be equal					
Welch Brown-Forsythe		1,114 1,114		77.06 77.06	0.0000 0.0000
Levene's test for variances		1,118		0.43	0.5141

Table 8: Analysis of variance for teacher mean scores in the electricity test.

The DE1 teachers' pupils (n = 172) scored an average of 34% and the DE2 teachers' pupils (n = 228) scored an average of 33% on the pre-test. Averages of 41% and 63% were scored by the DE1 and DE2 pupils respectively on the post-test. Twenty percent of the pupils scored two or less correct answers for the electricity test. Only 0.5% of the pupils scored 80% or more for the test. No pupils scored full marks. The teachers experienced specific difficulties (i.e., less than 50% of the sample group answered the question correctly) with questions 4, 7, 8, and 9a. The pupils experienced specific difficulties with the same questions with which the bulk of the teachers had difficulties, but the they also struggled with questions 5, 6 and 9b. A comparison of the number of teachers and pupils (post-test) correctly answering each question is shown graphically in figure 7

A comparison of the number of questions answered correctly by DE1 and DE2 pupils in the pre- and post-tests is illustrated graphically in figure 8, and numerically in table 9.

The data on pupil scores in the electricity paper reveals a statistically significant difference between the DE1 and DE2 pupils' understandings of this concept after tuition ($F = 106.24$, $p = 0.0000$). There was also a statistically significant difference between these groups pre-and post-test scores ($F = 106.24$, $p = 0.0000$). he interaction error was highly significant ($F = 41.11$, $p = 0.0000$).

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F VALUE	TAIL PROBABILITY
Pre-Post	482.7636	1	482.7636	106.24	0.0000
1-2 Year	143.9676	1	143.9676	31.68	0.0000
INTERACTION	172.7738	1	172.7738	38.02	0.0000
ERROR	1799.4189	396	4.5440		
Analysis of variance; variance are not assumed to be equal					
Welch		3,200		59.04	0.0000
Brown-Forsythe					
Pre-Post		1,345		114.58	0.0000
1-2 Year		1,345		33.88	0.0000
INTERACTION		1,345		41.11	0.0000
Levene's test for variances					
Pre-Post		1,396		1.56	0.2131
1-2 Year		1,396		1.41	0.2361
INTERACTION		1,396		3.06	0.0811

Table 10: Analysis of variance for pupil mean scores in the electricity test.

Overall, teachers did not score any better in the grade 6 electricity test than their pupils (Figure 9).

4.3 Measurement

The mean scores attained by teachers and pupils in the fractions pre- and post-tests are illustrated in table 11 below.

	DE1 (T)	DE1 (P)	DE2 (T)	DE2 (P)
Pre-test	54%	33%	61%	29%
Post-test	-	57%	79%	53%

Table 11: Comparison of teacher and pupil mean scores in the measurement test expressed as a percentage (T = Teachers; P = Pupils).

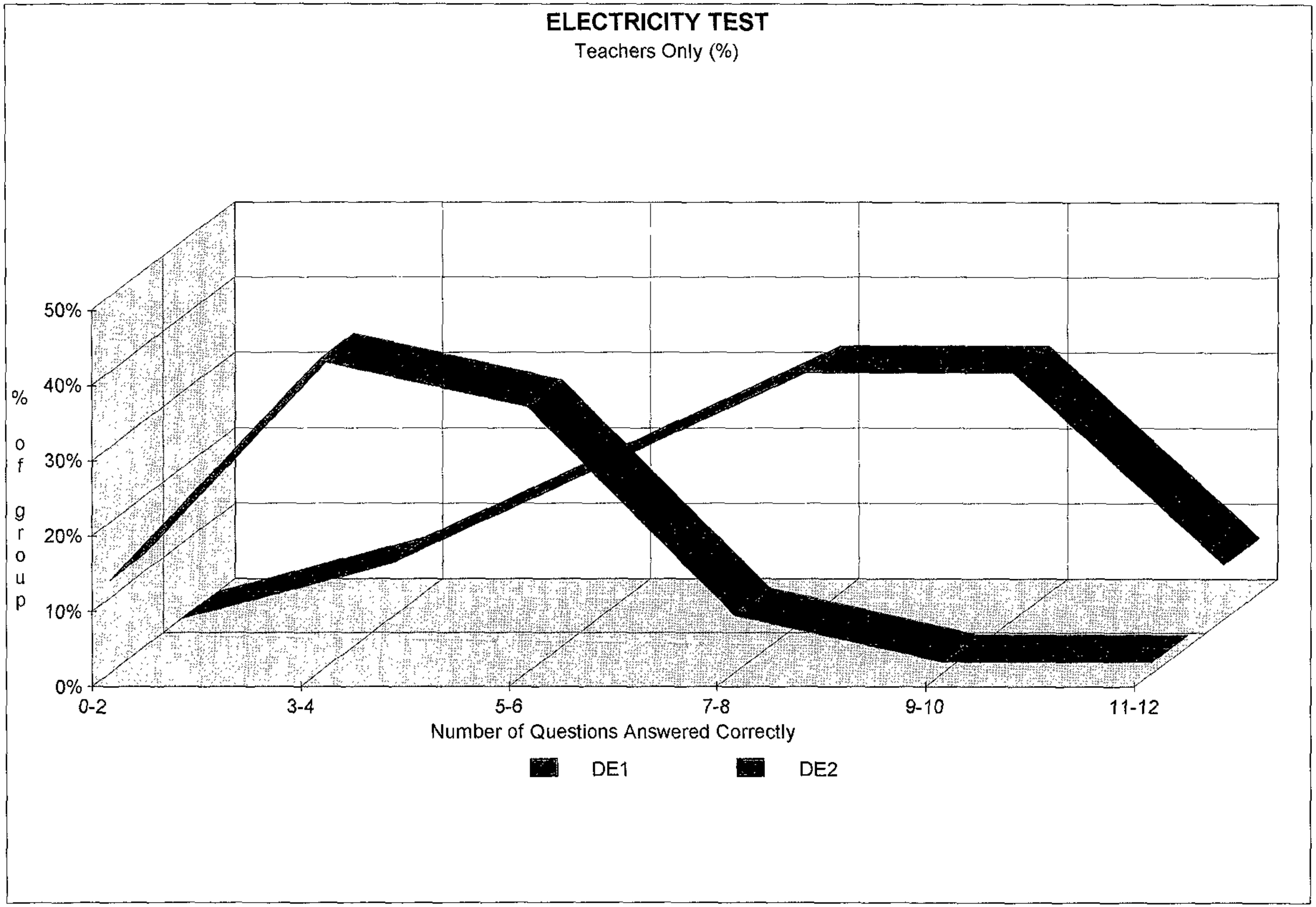


Figure 6: Comparison of DE1 and DE2 Teacher Scores in the Electricity Test

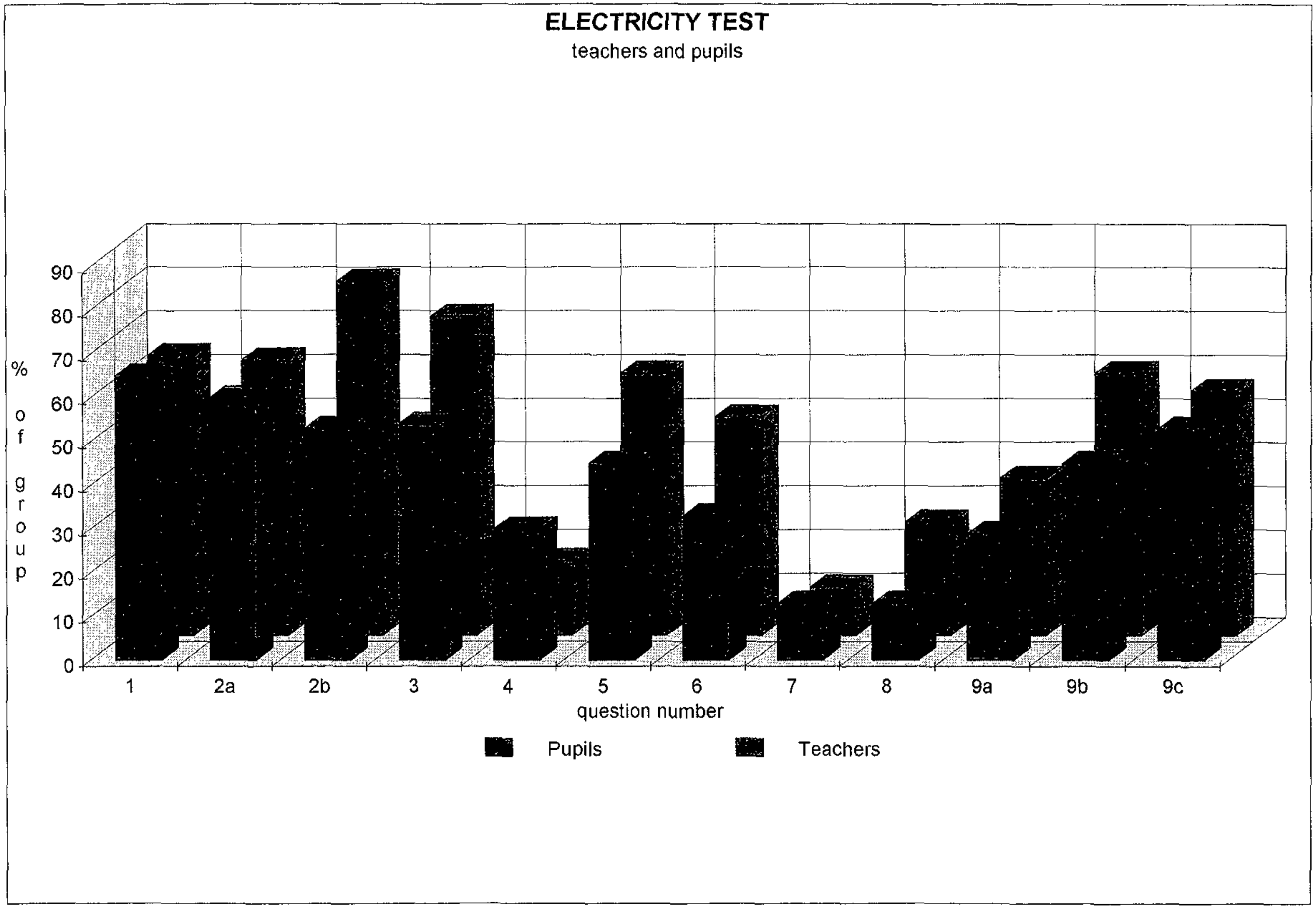
Number of Correct Answers
electricity test - teachers

	0-2	3-4	5-6	7-8	9-10	11-12	Total
DE1	8	27	23	5	1	1	65
DE2	0	4	11	18	18	4	55

Number of Correct Answers (%)
electricity test - teachers

	0-2	3-4	5-6	7-8	9-10	11-12
DE1	12%	42%	35%	8%	2%	2%
DE2	0%	7%	20%	33%	33%	7%

Table 7: Number of Teachers per Score in the Electricity Test (maximum mark = 12)



Fiigure 7: Comparison of number of teachers and pupils responding correctly to each question in the electricity test (expressed as percentage)

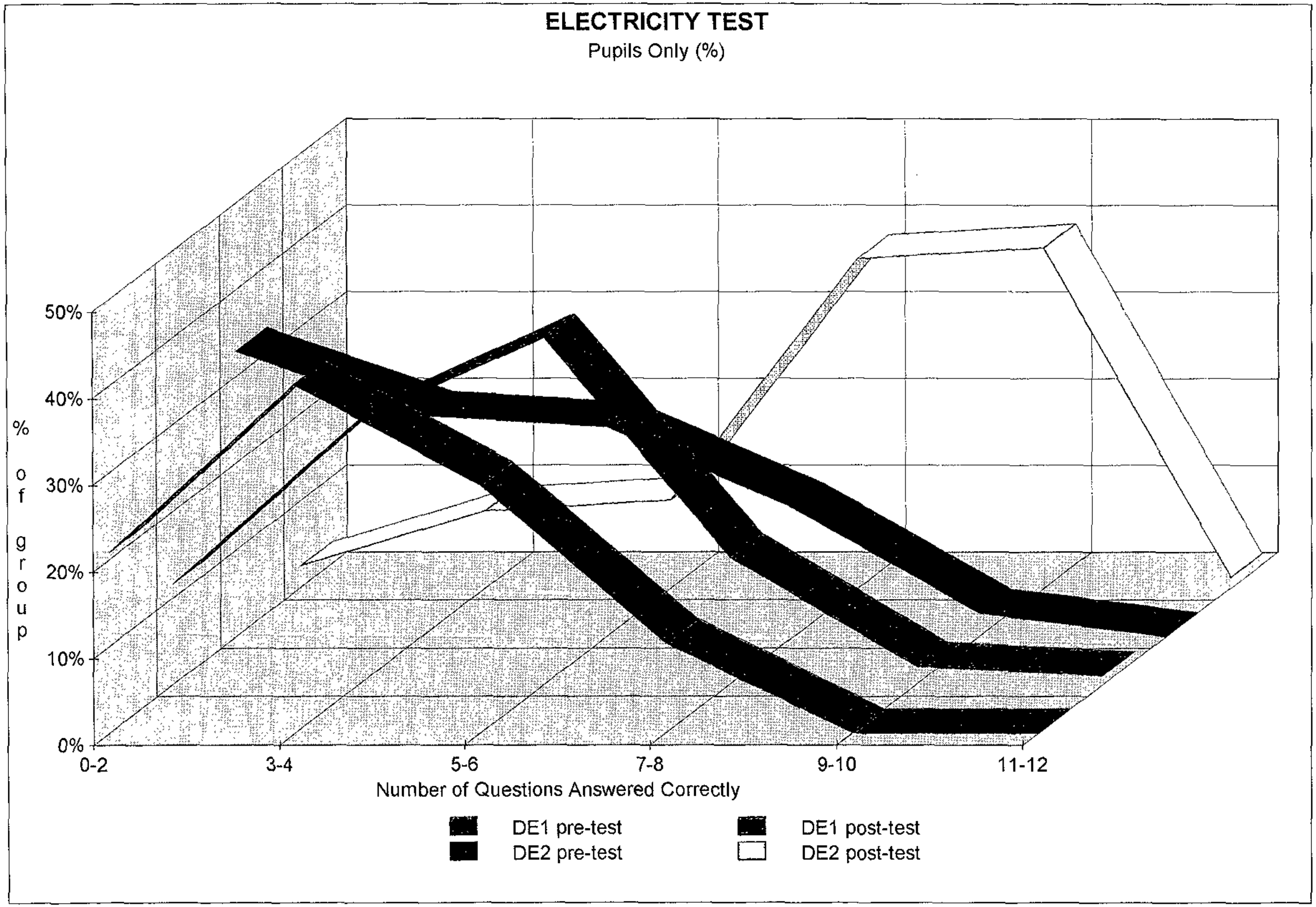


Figure 8: Comparison of DE1 and DE2 Pupil Scores in Electricity pre- and post-tests

Number of Correct Answers
electricity test - pupils

	0-2	3-4	5-6	7-8	9-10	11-12	Total
DE1 pre-test	16	31	22	8	0	0	77
DE1 post-test	11	29	38	14	2	1	95
DE2 pre-test	49	38	36	22	4	0	149
DE2 post-test	2	7	8	30	31	1	79

Number of Correct Answers (%)
electricity test - pupils

	0-2	3-4	5-6	7-8	9-10	11-12
DE1 pre-test	21%	40%	29%	10%	0%	0%
DE1 post-test	12%	31%	40%	15%	2%	1%
DE2 pre-test	33%	26%	24%	15%	3%	0%
DE2 post-test	3%	9%	10%	38%	39%	1%

Table 9: Number of Pupils per Score for DE1 and DE2 Pupils in pre- and post-tests on Electricity

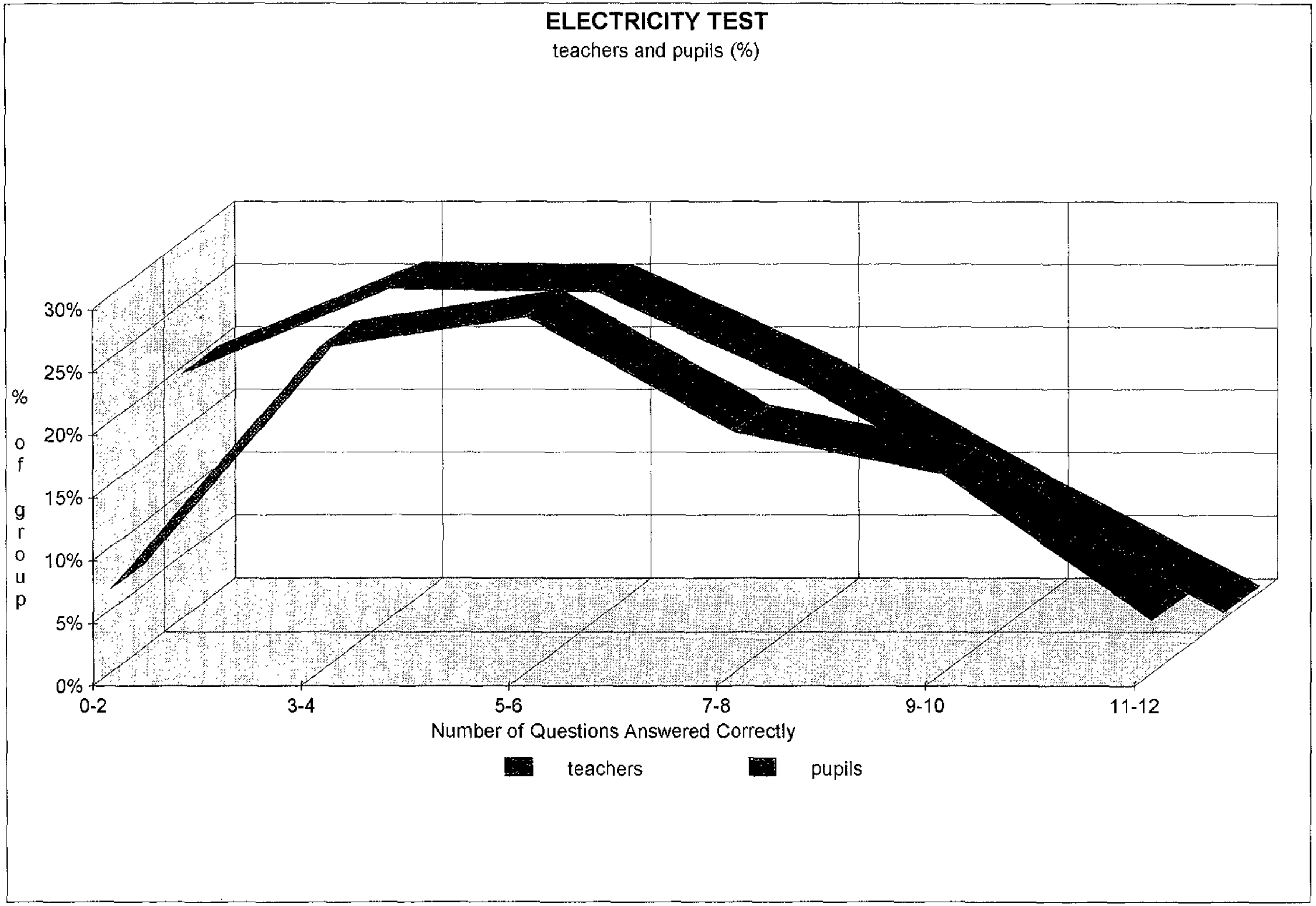


Figure 9: Comparison of Pupil and Teacher Scores in the Electricity Test

The average test scores achieved in the measurement pre-test by the DE1 (n = 97) and DE2 teachers (n = 49) were very similar, i.e. 54% and 61% respectively. However, there was a statistically significant difference (Table 13) between the DE1 teachers average pre-test scores and those attained by the DE 2 teachers in their post-test, i.e. 79%. Only 1 teacher (0.5% of the sample) scored two or less correct answers, while 14% of the group scored 95% or higher, i.e. 27 teachers. Of these, 15 of the 27 were DE2 teachers. A comparison of the number of questions answered correctly by DE1 and DE2 teachers is illustrated graphically in figure 10, and numerically in table 12.

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F VALUE	TAIL PROBABILITY
Tgroup	683.3691	2	341.6846	28.21	0.0000
Error	2362.1309	195	12.1135		
Equality of means tests; variances are not assumed to be equal					
Welch		2,108		40.49	0.0000
Brown-Forsythe		2,136		28.67	0.0000
Levene's test for variances		2,195		6.75	0.0015

Table 13: Analysis of variance table for teacher mean scores in measurement test.

The DE1 teachers' pupils (n = 340) scored an average of 33% on the pre-test while the DE2 teachers' pupils (n = 146) scored an average of 29%. Both groups improved their scores by 24% in the post-test, i.e. they scored an average of 57% (n = 101) and 53% (n = 73) respectively on the post-test. Eighteen percent of the pupils scored two or less correct answers in the measurement test. Five percent of the pupils scored 80% or more for the test.

The teachers experienced specific difficulties (i.e., less than 50% of the sample group answered the question correctly) with questions 2, 4, 10, and 18. The pupils experienced specific difficulties with the same questions with which the bulk of the teachers had difficulties, but the they also struggled with questions 5, 6, 7, 9, 10, 11, 12, 13, 14, 16 and 17. A comparison of the number of teachers and pupils (post-test) correctly answering each question is shown graphically in figure 11.

A comparison of the number of questions answered correctly by DE1 and DE2 pupils in pre- and post-tests on measurement is illustrated graphically in figure 12, and numerically in table 14.

The data on pupil scores in the measurement paper reveals a statistically significant difference (Table 15) between the DE1 and DE2 pupils' pre- and post-test scores, i.e. there was a significant improvement in their understanding of this topic after tuition (F = 276.54, p = 0.0000). The interaction was insignificant (F = 0.05, p = 0.8190).

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F VALUE	TAIL PROBABILITY
Pre-Post	2232.9033	1	2232.9033	276.54	0.0000
1-2 Year	59.6553	1	59.6553	7.39	0.0066
INTERACTION	0.4226	1	0.4226	0.05	0.8190
ERROR	5296.7631	656	8.0743		
Analysis of variance; variance are not assumed to be equal					
Welch		3,195		59.24	0.0000
Brown-Forsythe					
Pre-Post		1,210		174.29	0.0000
1-2 Year		1,210		4.68	0.0316
INTERACTION		1,210		0.03	0.8698
Levene's test for variances					
Pre-Post		1,656		182.48	0.0000
1-2 Year		1,656		19.87	0.0000
INTERACTION		1,656		15.86	0.0001

Table 15: Analysis of variance table for pupil mean scores in the *measurement test.*

Overall, teachers scored slightly better in the grade 7 measurement test than their pupils. (Figure 13).

Regression analysis was made of the scores of the teachers and their pupils for the fractions, electricity and measurement tests. There was a statistically significant positive trend between the scores of the teachers and those of their pupils as regards fractions (p = 0.0017) and electricity (p = 0.0286), i.e. there is a significant positive relationship between teacher knowledge and pupil outcomes. There was no statistical evidence of a positive relationship between the scores of the teachers and those of their pupils as regards the measurement test (p = 0.7903).

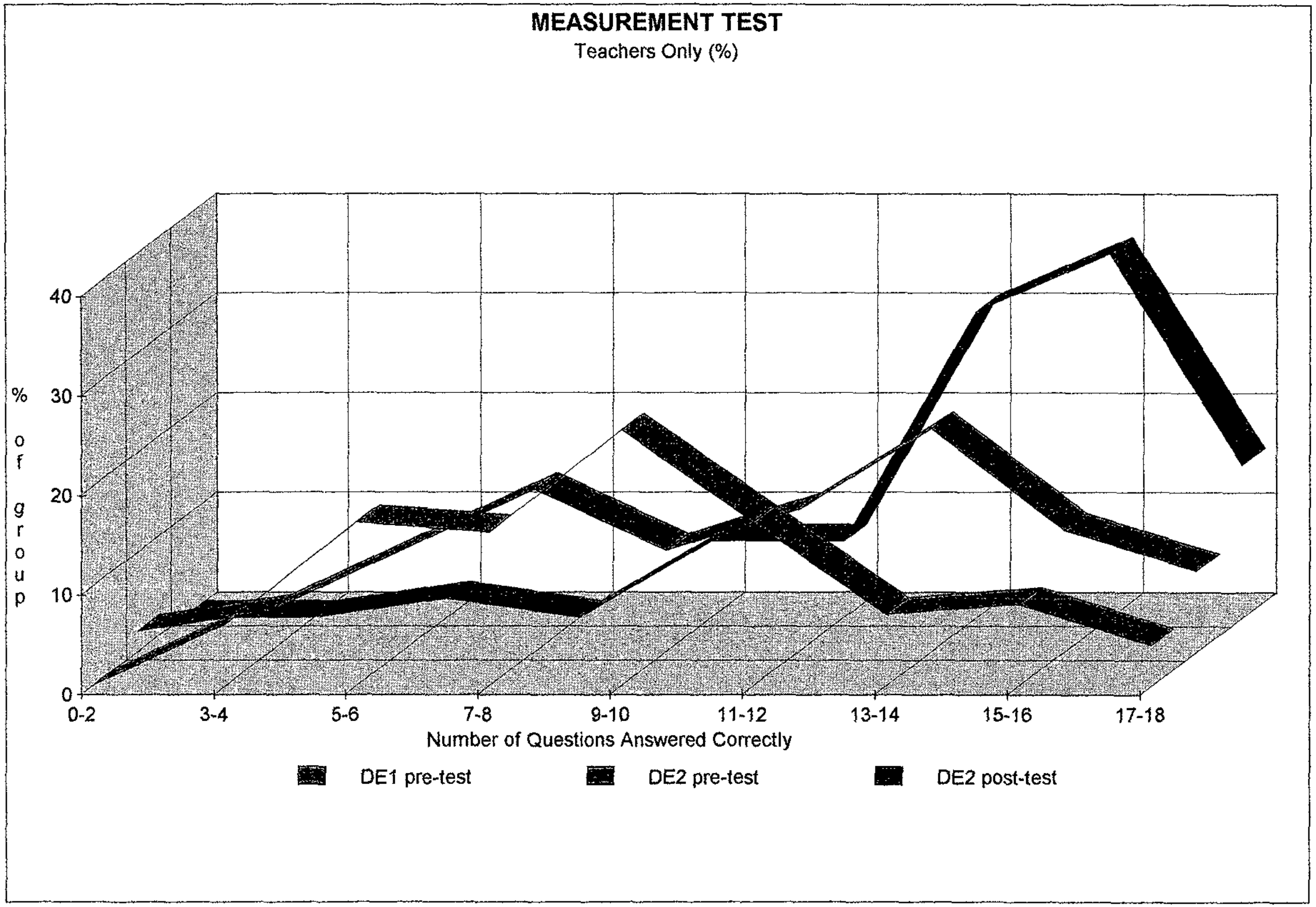


Figure 10: Comparison of DE1 and DE2 Teacher pre-tests and DE2 post-test, Scores in Measurement Test

Teachers Only										
	0-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	Total
DE1 pre-test	0	6	16	15	25	16	7	8	4	97
DE2 pre-test	1	2	5	8	5	7	11	6	4	49
DE2 post-test	0	0	1	0	4	4	16	19	8	52
Teachers Only (%)										
	0-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	
DE1 pre-test	0	6	16	15	26	16	7	8	4	
DE2 pre-test	2	4	10	16	10	14	22	12	8	
DE2 post-test	0	0	2	0	8	8	31	37	15	

Table 12: Number of Teachers per Score in pre- and post-tests on Measurement

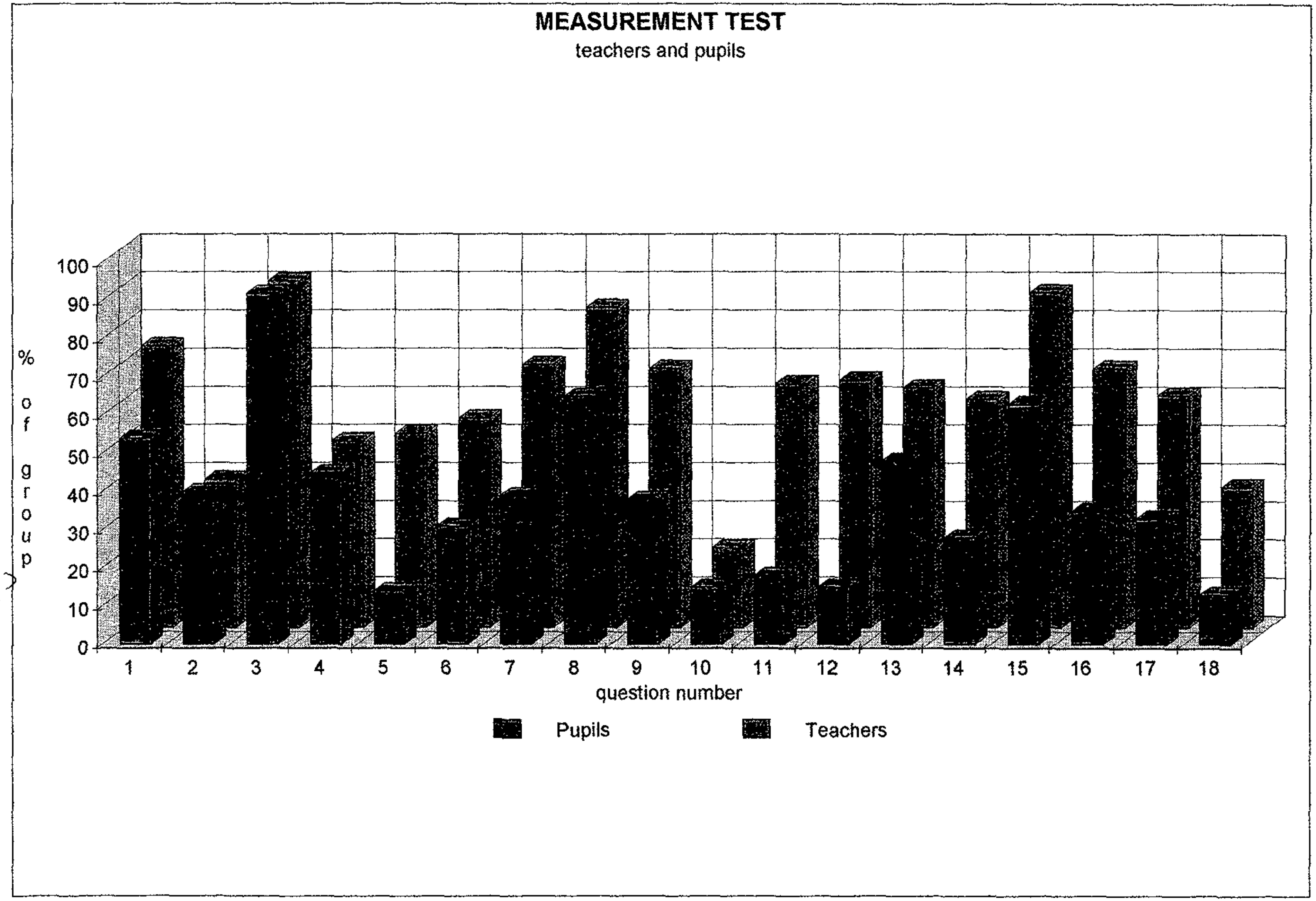


Figure 11: Comparison of number of teachers and pupils responding correctly to each question in the measurement test (expressed as percentage)

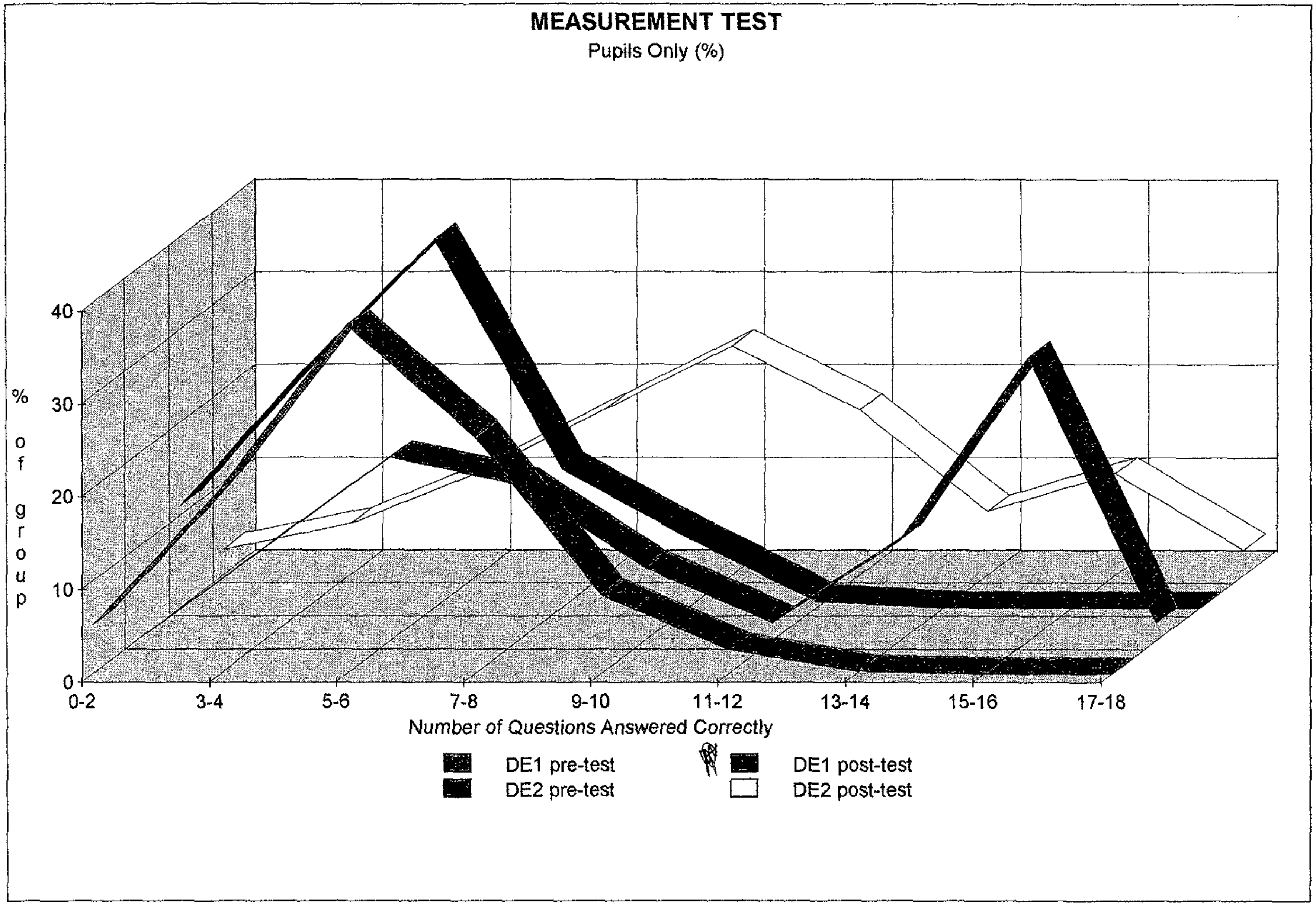


Figure 12: Comparison of DE1 and DE2 Pupil Scores in pre- and post-tests on Measurement

All Pupils									
	0-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	Total
DE1 pre-test	18	68	128	87	29	9	1	0	0	340
DE1 post-test	0	10	20	17	8	2	11	31	2	101
DE2 pre-test	16	38	58	22	11	1	0	0	0	146
DE2 post-test	2	4	8	13	18	13	5	8	2	73
Measurements Test (%)										
	0-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	
DE1 pre-test	5	20	38	26	9	3	0	0	0	
DE1 post-test	0	10	20	17	8	2	11	31	2	
DE2 pre-test	11	26	40	15	8	1	0	0	0	
DE2 post-test	3	5	11	18	25	18	7	11	3	

Table 14: Number of Pupls per Score in pre- and post-tests on Measurement

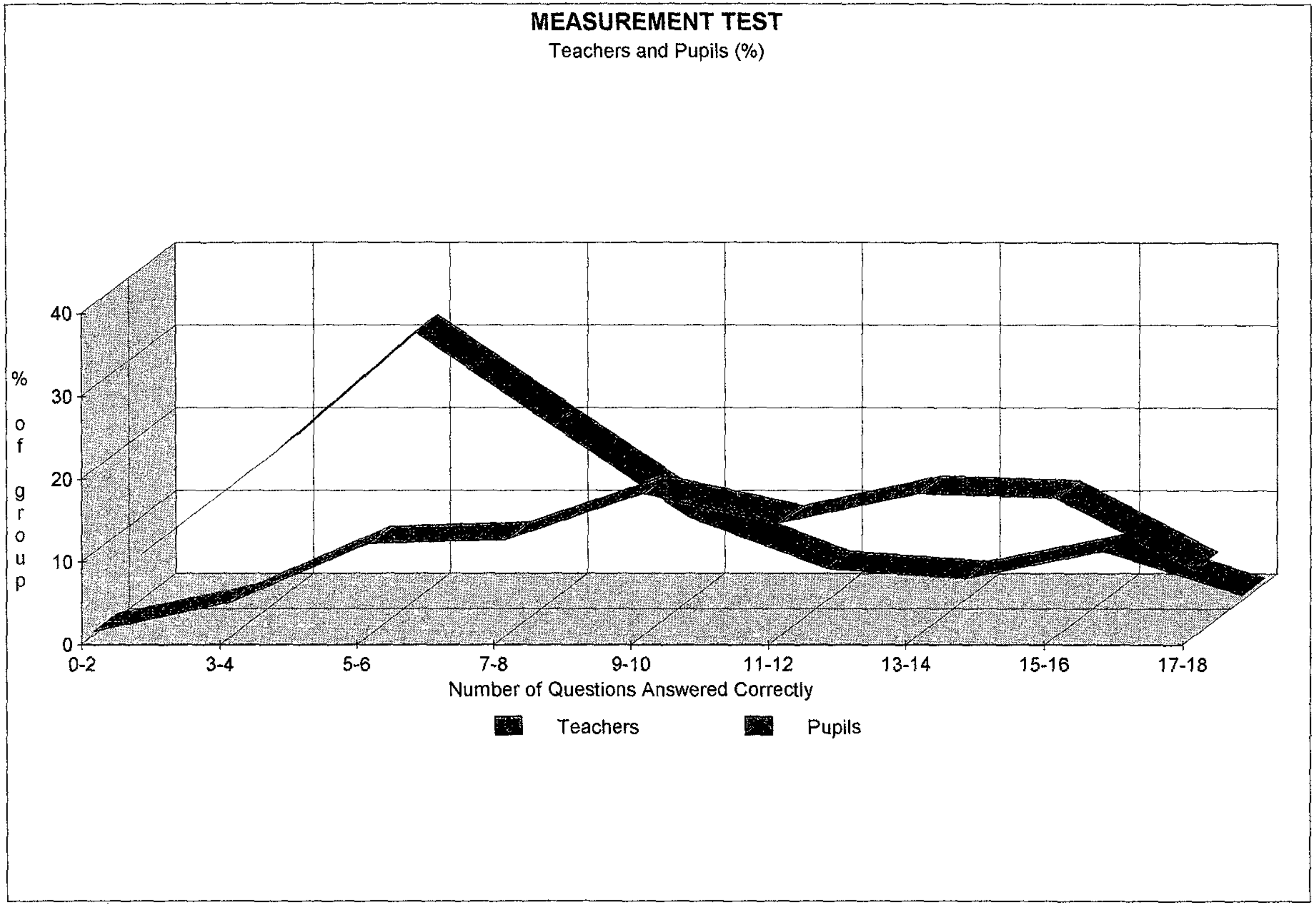


Figure 13: Comparison of Teacher and Pupil Scores in the Measurement Test

4.4 Classroom observations

The classroom observations were undertaken by a team of four researchers, three of whom worked together with teachers in the Queenstown area and the fourth worked with teachers in Port Elizabeth. A total of 20 Senior Primary teachers were observed, 10 DE 2 teachers and 10 DE 1 teachers.

In an ideal situation a more realistic picture of teacher performance in the classroom might have been obtained if teachers could have been visited without prior notice. However, this approach could not be taken as arrangements had to be made with teachers and principals of the schools. The teachers who were visited had all volunteered for the research programme and only those teachers who were currently teaching science and/or mathematics were chosen for the research classroom observations.

All 20 of the Senior Primary teachers observed taught either Grade 5 Fractions, Grade 6 Electricity or Grade 7 Measurement - the three areas that were tested for conceptual understanding. A total of 23 lessons were observed as 3 of the teachers taught two lessons each. A record of their individual scores attained in each component of the classroom observation schedule is shown in table 16. A comparison of DE 1 and DE2 teacher mean scores is illustrated in figure 14

4.4.1 DE2 Teacher observations

Within the group of 10 DE 2 teachers there was considerable variation in teaching styles ranging from one teacher who did not appear to have gained anything from the DE in terms of the alternate teaching strategies that had been modelled in the course (such as the use of group work and the use of practical teaching aids for the pupils), to those who competently adopted the methods promulgated by the course presenters.

The lesson observed being taught by the teacher referred to initially above was still 'teacher dominated', with information being transmitted to the pupils. At the other end of the spectrum there were teachers operating in learner centred classrooms with effective use of teaching aids and participatory group work taking place. The majority of the teachers fitted onto a continuum between these two situations with all the teachers (except the one who appeared to have gained nothing!) using groups in some way and using more than one teaching method that involved the pupils.

In three lessons the pupils were sitting in groups but were not working co-operatively. In only three lessons did some of the pupils use the apparatus while the rest of the group observed. Some teachers had limited apparatus which the members of the groups shared and in other lessons all the pupils had access to apparatus and were using it. In only one lesson did the pupils not handle any apparatus.

The level of discussion in the groups also varied from active discussion, possibly indicating a familiarity with group work, to other classes where little discussion took place. In seven of the eleven lessons where pupils were placed in groups there was group discussion, either spontaneously or motivated by the teacher.

In only four of the lessons did the teachers use any open ended questions. The usual style of questioning was to ask close-ended or simple recall questions. Encouraging the pupils to ask questions is still a problematic area as only three teachers managed to get their pupil ask questions. However, on the whole, the feedback to pupils answers to teacher questions was given in a way to encourage pupils to participate.

The use of English and Xhosa as media of instruction varied and related to a large extent to the context and situation of the school. In some of the rural schools most of the teaching took place in mother tongue but there were also rural farm schools in which English was used extensively and clearly understood by the pupils.

4.4.2 DEI Teacher observations

Observations in the DE1 teachers' classrooms revealed different styles of teaching. Ten teachers were observed teaching a total of 12 lessons. Four of the teachers used teaching methods that did not involve the pupils other than to have them chanting responses given by the teacher. In the remaining eight lessons the teachers used one or two methods which involved the pupils. None attempted more than two methods.

In only three classes did none of the pupils have the opportunity to manipulate apparatus. One of these classes had the smallest number of pupils! In all the other classes at least some of the pupils manipulated the teaching apparatus although in only two classes did all the pupils manipulate the apparatus.

Although the teachers used groups in eight of the lessons, in only five of the lessons was there any interaction among the group members, and this interaction was of a limited nature. In all but one lesson, the activities were teacher driven. None of these teachers asked open-ended or probing questions and in only one class did the pupils ask questions without teacher prompting. Only two teachers gave feedback to pupil responses in a way that encouraged further effort on the part of the pupils.

In the majority of lessons the teachers used English as a medium of instruction, reverting to mother-tongue when it was apparent that the pupils did not understand the language being used.

However, a factor that needs to be taken into account is class size. The largest class size that the DE2 teachers taught was 44 whereas, in the case of the DE1 teachers, six of the classes had over 60 pupils and the largest had 79 pupils. All the DEI teachers observed teach in schools in the Queenstown area.

4.4.3 Teacher knowledge and questioning

Application of Kendall Rank Correlation and Spearman Rank Correlation Tests for non-parametric data on the DE 1 and DE2 teachers' ratings for the *`teacher questions'* and pupil *questioning'* components of the classroom observation schedule, against *`teacher knowledge'*, i.e, their scores on the tests they wrote on the topics they were teaching, revealed significantly positive correlation *both* for teacher knowledge versus quality of question asked *and* teacher knowledge versus teacher ability to encourage pupils to ask questions (Table 17).

Teacher		Gr	Topic	1	2	3	4	5	6	7	8	9	10	Class size
DE 2 Teachers														
Bekape	1	6	Electricity	3	4	4	3	2	1	2	1	3	2	11
Swart	2	6	Measurement	4	4	4	3	4	4	4	4	4	4	40
Hurfkie	3	4	Fractions	4	4	3	3	4	4	4	4	4	4	35
Habavu	4	5	Fractions	3	4	3	2	1	2	2	1	1	4	44
Jacobs	5	4	Fractions	4	4	4	4	4	4	4	4	4	Afrik	40
Nkimbisa	6	3	Air	4	4	4	2	3	2	3	1	3	3	
Sapuka	7	8	Measurement	1	1	1	1	1	1	2	1	1	2	40
Fenge	8	7	Measurement	4	4	4	3	3	2	3	1	4	3	8
Fenge	8	3	Fractions	3	2	4	2	1	2	3	1	4	1	12
Szule	9	4&5	Fractions	3	3	3	3	4	4	4	1	4	1	18
Mlilo	10	6	Electricity	4	4	4	3	3	2	3	1	4	4	

Table 16: Classroom observation scores for DE1 and DE2 teachers (1 = variety of methods; 2 = learner materials; 3 = teacher materials; 4 = learner grouping; 5 = learners work in groups; 6 = critical thinking; 7 = teacher questions; 8 = learner questions; 9 = teacher feedback; 10 = use of language.

Teacher		Gr	Topic	1	2	3	4	5	6	7	8	9	10	Class size
DE 1 Teachers														
Tontsi	11	7	Measurement	1	1	2	1		1	2	1	0	3	69
Mdalana	12	7	Measurement	3	2	4	1		2	2	1	2	1	72
Bam	13	7	Measurement	2/3	2	2	3/2	1	2	2	1	3	4	63
Nomanova	14	5	Fractions	3	1	27	3	1	1	1	1	0	3	70
Fana	15	5	Fractions	3	2	2	2	1	2	2	1	2	1	68
Daniels	16	5	Fractions	2/3	2	2	1		1	2	1	1	3	53
Shenxana	17	5	Fractions	3	4	2	3	3	2	3	1	2	3	43
Shenxana	17	6	Electricity	3	2	3	3/2	3	2	2	1	2	1	35
Nomanova	14	6	Electricity	3	3	4	2	3	2	1	1	0	3	79
Booi	18	6	Electricity	3	3	2	2	3	2	2	1	0	3	48
Mtsha	19	6	Electricity	3	4	4	3	4	3	3	4	2	1	32
Tontsi Mrs	20	6	Electricity	2	1	4	1		1	2	1	4	3	25

Table 16 (cont.): Classroom observation scores for DE1 and DE2 teachers (1 = variety of methods; 2 = learner materials; 3 = teacher materials; 4 = learner grouping; 5 = learners work in groups; 6 = critical thinking; 7 = teacher questions; 8 = learner questions; 9 = teacher feedback; 10 = use of language.

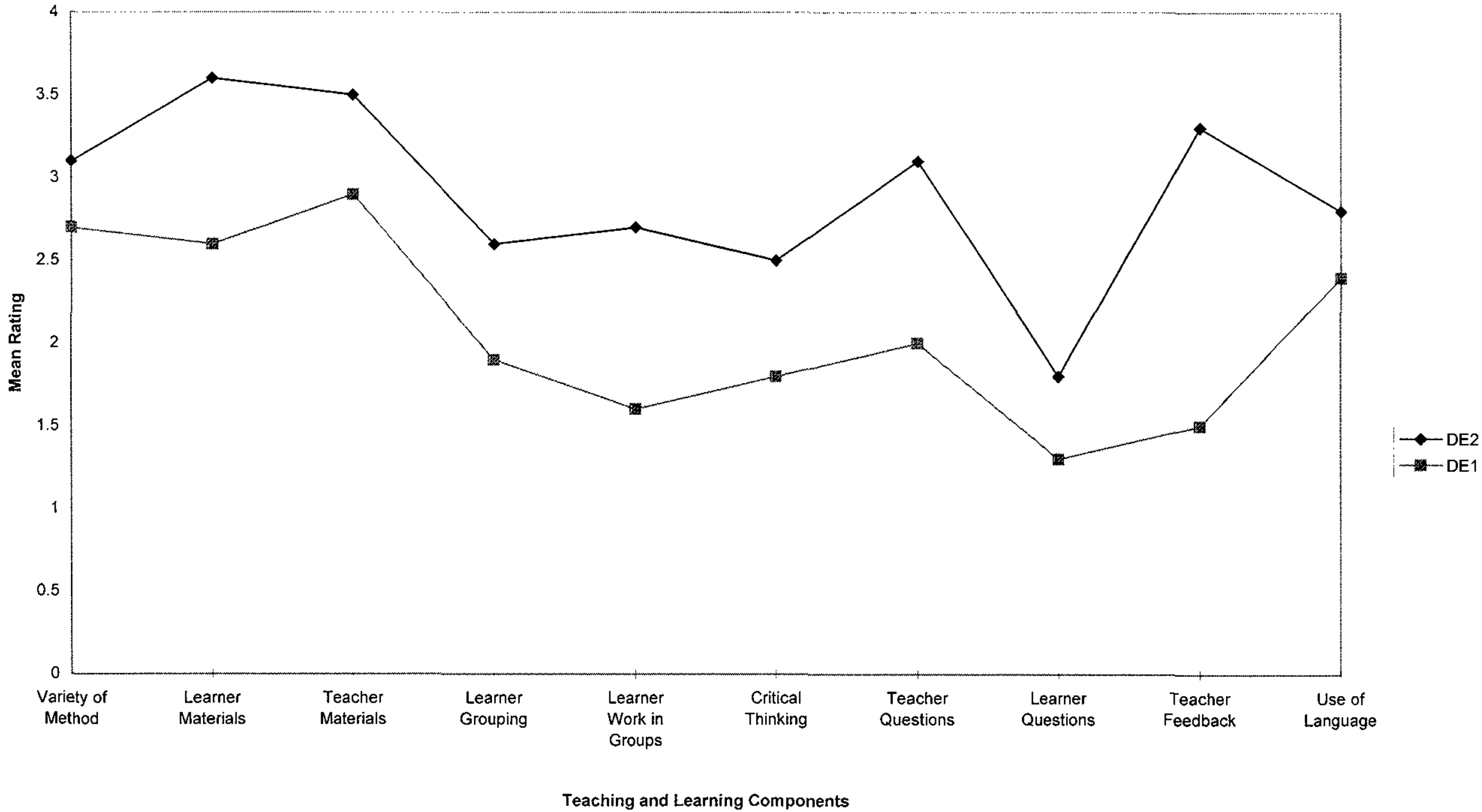


Figure 14: Classroom Observation Ratings of DE1 and DE2 Teachers

Score 1 = Test Score n = 13 Score 2 = Teacher Question (component 7) Score 3 = Pupil Questions (component 8)						
	Kendall RC	Z	p-value	Spearman RC	T (11 dof)	Rejected at alpha
Score 1 Score 2	0.673	3.2026005	0	0.7458	4.90603846	0.005
Score 2 Score 3	0.5344	2.5430457	0.0055	0.5572	2.777177539	0.01
Score 1 Score 3	0.3993	1.9001462	0.0287	0.4596	2.073569959	0.05
CRITICAL VALUES OF t-TEST (11 dof) to reject nul hypothesis (Ho)						
	alpha=0.005	Aplha=0.01	Alpha=0.025	Aplha=0.05		
	3.106	2.718	2.201	1.796		

Table 17: **Kendall and Spearman rank correlation tests correlating quality of teacher questions and teacher ability to elicit questions from pupils versus teacher subject knowledge (test score).**

4.5 Interviews

The original intention of including the semi-structured interviews as described and justified in the section on the research methodology was to be able to follow up the lessons that had been observed. In the reality of the research situation this did not happen. The threatened SADTU strike in June upset a number of plans as a number of teachers were not available at the times arranged and, where lessons were observed, there was insufficient time for more than brief interviews. It had been the researcher's intention to be present at all the observed lessons but this was not possible due to time restraints and as a result observations were shared among the other researchers/field workers. However, by initially attending the same lessons we were able to standardise the assessment of our observations.

A total of 11 teachers were interviewed - 3 DE2 teachers and 8 DE1 teachers. The other 7 DE2 teachers scheduled to be interviewed were from Port Elizabeth, but the researcher was unable to timetable these meetings. The students in the DE1 group were interviewed after they had been on the course for more than six months. All teachers were interviewed during the course contact sessions (classes) in Queenstown and, although this was less than ideal as the interviews often took place some time after the teachers had been observed in their classrooms, useful information was obtained.

Many of the interviews with the teachers ended up as conversations about their teaching and the impact of the course on their classroom practice rather than structured interviews. Perhaps this reflected the teachers' personal reactions to the interviewer as some teachers were easier to guide in the direction required. However, common features emerged from all the interviews. All the teachers acknowledged that the DE course had influenced the ways in which they were now teaching. (The DE2 teacher who had shown the least/no change in teaching practice was, unfortunately not available to be interviewed.) All the teachers said that they had been encouraged to try the 'new' methodologies presented in the course. Some mentioned that they had known about these methodologies before but had not had the confidence to try them. All commented on how well their classes responded to the activity based approaches. Two commented on the fact that the pupils come to the staff room should they (the teachers) not be in class on time as the pupils do not want to miss the lesson! All the teachers interviewed commented on the importance, for them, of the regular contact with the lecturers and their colleagues. A number of the teachers had previously registered for correspondence courses and had found them unsatisfactory and in some cases demotivating because *"when you have a question or problem the book cannot give you the answer".*

As the DE course modules do not focus on identifying key concepts in structuring lessons the question on this aspect was dropped. The information gained from the question on how learners acquire knowledge in Mathematics and Science was superficial in that the responses were that they gained the knowledge from actually doing the activities and therefore this question was not explored any further.

Most variety in responses came from questions on 'what part of the course has had the most influence on your teaching?'. For some it was definitely either the Mathematics or the Science modules and, for many, both these modules. Some specified the Communication module as they felt that this had given them the ideas and tools to implement some of the ideas from the Science and Mathematics modules. One teacher felt that the Education module had been the most useful for her. Some saw the Communication and Education modules as being "more theoretical" and the Science and Mathematics modules as "more practical", and noted that it was easier to catch up on the Science and Mathematics modules "because you could do them on your own", but found missed Communication and Education modules difficult to do on their own.

The teachers who had colleagues on the course found them supportive and some have motivated other colleagues to register next year. A few commented on how difficult it was introducing changes when they were criticised by their colleagues. The introduction of group work seemed problematic when they might be the only teacher using this method.

The notion of institutional outcomes was alluded to by some teachers. This notion has also been particularly noticeable during standard evaluation visits to schools where there appeared to be a palpable correlation between the number of teachers at any one institution registered for the Diploma in Education (DE) and the outcomes generated, e.g. sharing of ideas, implementation of strategies, successful pupil outcomes, support by management (heads of department and principals), enthusiasm, etc. Examples of such schools are Nokwanda Primary School where 9 of the 16 staff members are registered on the DE, Mina Soga Senior Primary School and Ithembelihle Primary School which each has five teachers on the course, and Junction Farm School where the entire staff (three teachers) participate in the programme. All of these schools are in the Queenstown district. The staff members of Junction Farm School have drawn teachers from surrounding farm schools into their own, self initiated, teacher development process.

For many their view of a 'good' teacher included being a caring person who takes an interest in their pupils - being warm and like a mother - being well prepared - and one included being punctual - being motivated and having teaching aids.

The time available for the interviews did not allow for further probing of some of their ideas but the conversations provided more insight about their views of teaching than paper and pencil tests alone could have done, as many DE teachers appear more articulate in conversation than writing.

4.6 Questionnaire

Data from the questionnaire based on an article in the Mail and Guardian giving guide-lines for choosing courses reveal that teachers on the DE have a very high regard for the course. They stated that they had received a course outline for the diploma (100% of the respondents, n = 123), that they were happy with the course outline (100%), that the course materials/handouts, etc. are outcomes-based (100%), that the course materials/handouts, etc. are interactive (96%), that the course materials do not merely provide information that requires memorisation (99%), that the assignments are based on classroom practice (95%), that all of their assignments were marked/assessed and returned to them and that they knew more or less when their assignments would be marked and returned to them (93%), that the subject-matter/content of the course is relevant to their professional development needs (100%), that they had been exposed to enough contact sessions (96%) and that they felt that they had received enough backup, assistance and support from their lecturers (100%). Also, 63% of the respondents rated the value of the course as extremely valuable while 35% rated it as very valuable.

5. DISCUSSION

The quantitative and qualitative data strongly suggest that the DE course has succeeded in bringing about changes in practice *towards what can be considered to be better Science and Mathematics teaching.* The quantitative data on teachers' knowledge clearly indicate that the teachers who have been on the in-service course focusing on Science and Mathematics Education for more than a year (DE2 teachers have significantly better understandings of fractions, electricity and measurement than do their peers who have not been exposed to this type of intervention (DE1 teachers at the beginning of the course). In tam, this has been translated into significantly better pupil outcomes in these subjects in the classroom

It may be appropriate at this juncture to note that the large sample sizes used for the statistical analyses in this research project have led to highly reliable statistical inferences. The fact that the results are basically similar in all three data sets, i.e. fractions, electricity and measurement, further confirms that the conclusions of this study are highly motivated from a statistical point of view.

5.1 Fractions

Firstly, it is clear that the DE2 teachers are more able when working with fractions 'than the DE1 teachers. It is also clear that the teachers are significantly more able than their pupils in this topic and that the pupils benefit significantly from instruction.

The data from the test on fractions (attachment 2) indicate that the pupils of DE1 teachers fared significantly worse in both the pre- and post-test on fractions than did the pupils of DE2 teachers. However, both the DE I and DE2 pupil groups improved their average scores by 12% after tuition, resulting in average scores of 31% and 43% respectively. There is no statistically significant interaction, i.e. the improvement may not statistically be attributed to the different groups of teachers teaching abilities, viz. DE1 and DE2 teachers. Nevertheless, regression analysis of teacher and pupil scores in the fractions test clearly reveals that the more the teacher knows about the subject, the better the pupils fare!

Also, it is sensible to expect that the higher the base line from which the pupils moved, i.e., the higher the pre-test average score, the more difficult it was to improve by 12%. The higher pre-test score by DE2 pupils may possibly be attributed to an overall enhancement of instruction in mathematics by DE2 teachers, resulting in a transfer of mathematical understandings to the area of fractions before tuition and thus affecting the pre-test scores. However, this is speculative and requires further investigation.

The first question on fractions (attachment 2) which both teachers and their pupils had difficulty with is question 3. They had great difficulty in subtracting 5/16 from 1. Discussion with the students has revealed that the concept of fractions other than halves and quarters is very limited. Even at grade 7 level teachers are inclined to progress no further than halves and quarters in their teaching. Also, discussions revealed that the Xhosa term 'ihalfana' describes the division of something into parts, irrespective of the size of these parts, i.e. there need not be equality. The notion of a 'big' half and a 'smaller' half is therefore quite acceptable. This probably has an impact on how Xhosa speaking children approach fractions.

The second question with which both teachers and pupils alike had difficulty is question 15. This asked 'What fraction is represented by the letter B on the number line?'. One teacher counted the divisions towards B by adding one to the denominator on each count, ie 1/1,, 1/2, 1/3 etc. Another teacher counted on from 1/5 in a similar fashion, viz. 1/5, 1/6, 1/7, 1/8 etc. One teacher was not sure from which end of the number line to begin counting. She measured that B was 1/5 from the end of the number line and therefore it represented 1/4. Again the misconception came to the fore that there must always be representations of halves and quarters. A teacher estimated that B was 1/4 from the halfway mark and therefore B represented 1/4. Another teacher counted 9 division lines on the number line. B was on the seventh division and therefore its value was 7/9.

Question 20 asked whether 0.001 is the same as; one tenth, one hundredth, one thousandth or one ten-thousandth. This question is a fairly simple one on a basic concept. However, again both teachers and pupils struggled to make sense of this question. It could be expected that to move from an understanding of fractions to one of decimal fractions is a natural progression. However, it appears that this is not the case if the learners have not grasped basic concepts of fractions and are not able to compare fractions. This suggests that teachers have a serious problem in understanding place value of fractions, especially place value after a decimal sign.

5.2 Electricity

The DE2 teachers scored significantly better than the DE1 teachers did in the electricity test. However, the DE2 teachers did not record significantly higher scores in their tests compared to their pupils post-test scores, i.e. 65% and 63% respectively. What is even more interesting is that not only is the DE1 teachers' knowledge in this topic very weak, but that they did not even fare as well on average as their pupils did in their post-test, i.e. 37% and 41% respectively!

The results of the pupil tests on electricity (attachment 4) are less equivocal than were the results of the fractions research. There was no significant difference between the scores of the pupils of DE1 and DE2 teachers on pre-tests in this topic, viz., 34% and 33% respectively. However, after tuition, there was an undoubtedly significant difference between the scores of the pupils of DE1 and DE2 teachers, viz., 41% and 63% respectively.

Two-way analysis of variance indicates that not only did the pupils of DE2 teachers achieve significantly better in the electricity post-test than the pupils of DE1 teachers did, but that the treatment effect as regards electricity is considerable. This means that the significantly better performance by DE2 pupils may be attributed to significantly better teaching by their teachers. This is supported by regression analysis of teacher and pupil electricity scores, i.e. these data reveal that the more the teacher knows about the subject, the better the pupils fare.

The first question in the electricity paper (Attachment 4) with which both teachers and their pupils had difficulty was question 4. This question required an understanding that unlike charges attract one another and that electrons can move on an object. It also requires an understanding that a redistribution of charges can create a dipole, allowing attraction by oppositely charged parts of the objects. Few teachers and pupils were able to determine two correct statements, however many knew that unlike charges attract. The concept of charge is a fairly abstract one and therefore pupils might be expected to experience difficulties. However, as it underpins many of the ideas required to understand electrostatics it is vital that all teachers have a clear grasp of this concept.

The pupils also had problems with questions 5 and 6, suggesting an inadequate conception of charges and how they relate to lightning. Question 5 is not a higher order understanding and is one that pupils at grade 6 level should be able to grasp. In contrast, the understandings required to be able to make sense of the phenomenon of lightning (question 6) are varied and abstract, and one could reasonably expect pupils to find the scientifically accepted explanations difficult to accept. Alternative conceptions of lightning as related to witchcraft have been documented in the South African context (Moodie ca 1990) and may impact on teachers' ability to internalise the scientific explanation of this natural occurrence. This in turn would impair their ability to teach this concept adequately.

Questions 7, 8 and 9 revealed problematic understandings in both teachers and pupils as regards electric current and circuits. Alternative conceptions of electricity are universal, e.g. 'clashing-current theory', 'current-is-used-up theory', etc., and have been widely reported by researchers (Osborne 1983, Webb 1992). These alternative ideas need to be made explicit to teachers and are worthy of particular attention by science teacher educators. Teachers also need to be made aware of the value of making these alternative conceptions explicit to pupils and of the positive effect of allowing children to challenge these ideas empirically.

5.3 Measurement

The data on measurement skills indicate no statistically significant difference between the scores of DE 1 and DE 2 teachers on pre-tests (attachment 6) in this topic, viz., 54% and 61% respectively. However, after tuition, the DE 2 teachers attained a statistically significantly higher score, viz. 79%. Not only was the DE1 teachers' knowledge in this topic weak, but they did not even fare as well on average as their pupils did in their post-test, i.e. 54% and 57% respectively

There was no significant difference between the pre-test scores of the pupils of DE1 and DE2 teachers, viz., 33% and 29% respectively. Both groups' marks improved by 24% in the post-test, and the mean change remained statistically insignificant. The insignificant interaction recorded does not allow any comment to be made as to the different groups of teachers' teaching abilities, viz. DE 1 and DE2 teachers.

However, the bimodal nature of the DE2 post-test curve (Figure 12), with a second peak at 13 - 14 correct answers out of 18, suggests the possibility that one or more DE1 teachers may have managed to retain a copy of the pre-test and primed their pupils for the post-test questions. This notion is supported by the fact that these data are inconsistent with what was recorded in the fractions and the electricity tests, both in overall scores and the modality of the curves, and by the fact that the number of pupils at this peak falls within one or possibly two class sizes. That two groups (classes) of pupils had identical incorrect answers within the groups also lends strong support to this theory. If these scores are removed from the statistics, the DE 2 pupils fare significantly better than the DE 1 pupils and the difference in score may be attributed to the teaching they received.

The fact that regression analysis indicates no statistically significant positive trend in the relationship between teacher and pupil scores in the measurement test is also not disconcerting as the same argument that is used in the paragraph above may be used to explain this inconsistency.

Both teachers and pupils had difficulty reading a scale that was not demarcated in units of one. This was indicated by the poor performance by both groups in questions 2 and 4 of the measurement test (attachment 6). Both groups also had difficulty converting kilometres from a decimal fraction to a whole number of centimetres (question 10). Teachers were able to cope with simpler conversions (question 9). Both teachers and pupils struggled to visualise the number of cubes in a three-dimensional stack (question 18). Teachers could visualise the number of cubes using a two-dimensional stack (question 17), but the pupils were unable to do so.

In general the pupils performed badly when taking simple measurements (questions 5 and 6), struggled to relate the concepts of volume and displacement (question 7), could not calculate perimeter or area of a rectangle or a circle (questions 11, 12, 13 and 14), nor were they able to visualise the hidden `faces' of a rectangular block.

The fact that South African pupils experience great difficulty when reading scales, converting units and visualising volumes in three dimensions has been reported in other research findings (Wessels 1998). This study suggests that this is true too of many teachers. In fact the DEI teachers scored only 54% on the measurement test, while their pupils achieved 57%! As the DE1 teachers are seen to be a subset of a larger pool of underqualified teachers, this finding may be an important warning sign and call for serious consideration in both INSET and PRESET teacher education.

5.4 Implications

Despite the relatively poor success rate by teachers on tests designed for their pupils, the findings in this study clearly show that the basic requirements of the first-order `knowledge and skills' INSET outcome as described by Kinder and Harland (1997) have been met by this Continuing Professional Development course (the Diploma in Education focusing on Science and Mathematics). However, it is disconcerting that a number of teachers cannot successfully complete tests on fractions, electricity, and measurement at grade five, six and seven level respectively. This is probably indicative of the inadequate schooling and initial teacher training that many teachers have received in South African institutions. Nevertheless, the diagnostic value of the tests is of great importance as it can be used to inform constructivist practice in teacher training, i.e., provide indicators of shared misconceptions held by teachers and pupils and highlight particular areas where both groups need assistance in order to develop adequate skills.

5.5 Classroom observations

The information obtained from the classroom observations in this study is very interesting and is useful in indicating trends in changing classroom teacher/pupil interactions. Although the general teacher evaluation form (attachment 8) used for DE classroom evaluation does not follow the same format as the research instrument (attachment 9), the information it provided via a large data set supports the notion that the limited sample of classroom observations used in this research study can be generalised to the DE population. The following discussion, therefore, is largely based on the classroom observations of the 20 teachers who volunteered to participate in this aspect of the research project.

With three exceptions, the teachers were only observed for one lesson. Personal experience from observing PRESET student-teachers cautious one from believing that the majority of lessons taught in the normal run of teaching will be like the ones observed, but it does at least indicate what the teachers are capable of doing. The majority of the lessons observed reflected closely the structure that was used in the DE course. The fact that the teachers felt confident enough to try out the new teaching strategies with their classes is a tribute to the lecturers on the course for the support that they have given the teachers. In some cases, especially the lessons on fractions given to grade 5 pupils, the level of work done with the pupils was much easier than grade 5 pupils should be doing in fractions. In one specific lesson, the pupils' classwork books revealed that the class had been doing more advanced work but for the observation lesson the teacher chose to demonstrate work that she had already done. It is likely that this happened in a number of the lessons observed but does not detract from the findings.

With the exception of the few teachers who showed very little change in their teaching, it is interesting to note a trend in the order in which aspects of classroom practice change. Changing teaching strategy, such as using practical teaching aids with which the pupils can manipulate and interact, appears to one of the first changes to be observed. Even in quite 'deprived' schools with almost no resources available to the teachers, they managed to collect teaching aids, in a number of cases with the help of the pupils, which could be used practically in their lessons. The physical classroom arrangement of the pupils into groups was done by most of the teachers but, in a number of cases and especially among the DE1 teachers, although the pupils sat in groups, they worked individually. It would seem that the development of the skills needed for managing groups is something that is only developed in the second year of the course and, even then, not all the DE2 teachers were able to achieve effective group interaction. Perhaps group management skills need to be developed more explicitly in the DE course.

From these observations it would seem that the most difficult aspect of teaching to change is teachers' questioning skills and their ability to encourage pupils to ask questions. Only a few DE2 teachers encouraged pupil questions and were able to ask open-ended questions. Only one DE1 teacher encouraged pupil questions but was still not asking open-ended questions. Nevertheless, statistical analysis showed a significantly positive correlation between both teachers' ability to ask quality questions, and their ability to elicit pupil questions, versus teacher knowledge of the topic being taught. This is yet another finding of this study which appears to fall within the ambit of Harland & Kinder's (1997) ordering of INSET outcomes.

In general, evidence from the classroom observations shows that the course has succeeded in bringing about changes in practice towards what is considered to be *better Science and Mathematics teaching.* Establishing the precise reasons for this change is a much more difficult task, although a number of trends are apparent which can be made explicit within the framework of INSET outcomes described in this study.

5.6 Interviews

Teachers' accounts of the impact of the INSET scheme on their practice made clear that the in-service activities had had a very varied influence; different teachers in effect nominated different outcomes accruing from the same INSET provision. This is in concordance with Harland & Kinder's (1997) assertions as regards the impact of INSET.

The interviews also reveal that the teachers may be thinking about their teaching more than is revealed in classroom practice. This appears to be the case with the DE1 teachers who have not yet shown the same changes as the DE2 teachers but who have verbally articulated the ideas promoted by the course. An interesting follow-up question for investigation could be *'what triggers teachers into implementing new ideas and strategies'?*

5.7 Questionnaire

The responses given to the questions on the questionnaire reveal that the teachers perceive that the course complies with what is regarded as a *'good course'* of study and suggests a high degree of *value congruence* between the developers of the DE and the in-service teachers who are registered as students. Value congruence is recognised as a high order INSET outcome and one which requires careful attention when developing and executing any professional development programme for teachers.

6. CONCLUSION

It is clear that the teachers who have been on the DE for more than a year have significantly better understandings in Science and Mathematics than their peers who have not been exposed to this type of intervention. This has been translated into significantly better pupil outcomes in these subjects in the classroom. Also, where difficulty is experienced with aspects of Science or Mathematics, misconceptions may be shared - sometimes by teachers, sometimes by pupils and, in some cases, by both pupils and teachers. Diagnosis of these shared misconceptions is potentially of great value in informing better practice, both for teachers when teaching their pupils and for the developers of INSET courses.

One of the first INSET outcomes to manifest itself in the classroom is the use of practical teaching aids by teachers in their teaching. Another is the physical re-arrangement of classrooms to allow pupils to sit in groups. However, this does not mean that the pupils arranged in this way automatically work co-operatively and it is suggested that group management skills be taught explicitly in INSET courses.

It appears that the most difficult aspect of teaching to change is teachers) desire and ability to ask questions of their pupils and, in turn, to get their pupils to ask questions of them. It is suggested that this reluctance may be linked to teachers)lack of conceptual understanding of the topic being taught. This in turn may be linked to teacher confidence.

Evidence from classroom observations shows that the course has succeeded in bringing about changes in practice towards what is now considered to be better Science and Mathematics teaching. However, teachers' accounts of the impact of the INSET scheme on their practice made clear that the in-service activities had had a very varied influence; different teachers in effect nominated different outcomes accruing from the same INSET provision.

The INSET outcomes produced by the DE focusing on Science and Mathematics and identified by this study fit comfortably within Harland and Kinder's (1997) hierarchy of outcomes. There are clear indications that all of their third, second and first order outcomes were met to varying degrees by the DE course and that these outcomes had differing effects on teachers, despite the same intervention. It is also clear that the dominant outcomes generating `best practice' are the first order outcomes of improved knowledge and skills and a high degree of value congruence.

The classroom evaluations, interviews and testing of teachers and pupils support the notion that the impact of the above outcomes on change in classroom practice can be evaluated against a number of indicators such as, amongst others, the frequency and amount of Science and Mathematics tuition being undertaken by teachers; the intentionality and planning underpinning the Science and Mathematics activities provided for pupils; the organisation and management of these activities in the classroom; the nature of the interactions between teachers and pupils; the nature of the knowledge and skills of teachers and the achievements of pupils in Science and Mathematics.

It appears important that the specific outcomes that could be expected from any particular teacher development programme need to be made explicit when developing the curriculum. Also, an attempt should be made, where possible, to nurture all outcomes. Only then can the intervention be realistically expected to successfully generate 'best practice'. In contrast, without investigations into specific outcomes and their effects, teacher INSET is in danger of remaining at a level of generality that is insufficiently defined and precise to be of much assistance to policy makers, planners and practitioners.

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