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Teacher Action Research and Constructivist Classroom Environments in South Africa

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INTRODUCTION

The primary aim of the present research was to seek information to assist South African teachers to become reflective practitioners in their daily mathematics classroom teaching. The study involved a combination of quantitative and qualitative research methods, including administration of the Constructivist Learning Environment Survey (CLES). In the first phase of the study, the CLES was administered to 1864 learners in 43 classes, and its validity with this sample was checked. During a 12-week intervention phase, a teacher used CLES profiles to assist her to develop strategies aimed at improving the constructivist orientation of her classroom learning environments.

OBJECTIVES

The objectives of this study were to:

- modify and validate an actual and a preferred version of the *Constructivist Learning Environment Survey* (CLES) for use at the intermediate and senior levels of schooling in South Africa.
- investigate whether teachers are able to make use of student responses to the CLES to develop and implement action research strategies for improving the learning environment.

BACKGROUND AND THEORETICAL FRAMEWORK

Field of Learning Environments

Walberg and Moos initiated the field of learning environments research in the 1960s. Moos developed his first world-renowned social climate scales, which were used in hospitals and correctional institutions (Fraser, 1986, 1998). At around the same time, Walberg developed the *Learning Environment Inventory* (LEI), which was used for the research and evaluation activities of the Harvard Project Physics (Walberg & Anderson, 1968). Since that time, researchers have developed numerous questionnaires, designed to measure perceptions of a range of dimensions pertinent to the learning environment (Fraser, 1998).

Education in South Africa

Since the new South African government came into existence in 1994, the education Minister, Professor Bengu, embarked on changing the education system. It was decided that, from 1998, the system under which blacks, Indians, coloureds and white students study different curricula would be phased out and gradually replaced by *Curriculum 2005* (Department of Education, 1997). *Curriculum 2005* is based on the ideal of lifelong learning for all South Africans, regardless of colour, race or sex. This curriculum focuses on fostering learning that encompasses a culture of human rights, multilingualism, multiculturalism and

sensitivity to the values of reconciliation and nation building (Department of Education, 1997). To ensure success, the curriculum aims to provide support in the form of inservice teacher training, assessment, guidelines and student orientation.

Curriculum 2005 encompasses an outcomes-based approach to education. The methods employed are learner-centred and emphasise skills that students require to become better citizens in the future. The classroom environment advocated through *Curriculum 2005* involves students participating in classroom activities, becoming more involved in the learning process and taking responsibility for their own learning. Also it requires that teachers give students the opportunity to work at their own pace according to their individual abilities and levels of development. One means by which teachers might be able to improve their classroom environments and teaching practices could be through reflective practice. The primary aim of this study was to seek information that will assist teachers to become reflective practitioners in their daily classroom teaching.

According to constructivist theory, knowledge is a social construct (Taylor, Fraser & Fisher, 1997). *Curriculum 2005* advocates the use of constructivist teaching methods to ensure a more student-centred classroom. Our study examined how mathematics teachers in South Africa transform their classrooms from ones that are more traditional and teacher centred, towards ones that include teaching methods that reflect a more constructivist notion of teaching. To do this, we used the *Constructivist Learning Environment Survey* (CLES; Taylor, Dawson & Fraser, 1995; Taylor & Fraser, 1991; Taylor, Fraser & Fisher, 1997).

Using the CLES to Monitor Transformation in South Africa

The CLES was developed to provide feedback on teachers' attempts to transform their classroom learning environments in accordance with critical constructivist epistemology (Taylor, Dawson & Fraser, 1995). The CLES was developed in 1991 (Taylor & Fraser, 1991) to enable teachers to monitor the transformation from a more teacher-centred approach to more constructivist teaching approaches and to address key restraints to the development of constructivist classroom climates in school science and mathematics (Taylor, Fraser & Fisher, 1997).

The CLES assesses students' and teachers' perceptions of five dimensions pertinent to the notion of constructivism: *Personal Relevance* (the extent to which teachers relate science and mathematics to students' out-of-school experiences); *Uncertainty* (the extent to which opportunities are provided for the students to experience mathematics and science knowledge as arising from theory-dependent inquiry, involving human experience and values, evolving and non-foundational, and culturally- and socially- determined); *Student Negotiation* (the extent to which opportunities exist for students to explain and justify to other students their newly-developing ideas and to listen to and to reflect on, the viability of other students' ideas); *Shared Control* (the extent to which students are invited to share with the teacher control of the learning environment, including the articulation of their own learning goals, design and management of their learning activities, and determination and application of assessment criteria); *Critical Voice* (the extent to which there has been established a social climate in which students feel that it is legitimate and beneficial to question the teacher's pedagogical plans and methods and to express concerns about any impediments to their learning).

The CLES is available in an actual and a preferred form (Kim, Fisher & Fraser, 1999), with the preferred form being concerned with goals and value orientations and assessing the learning environment that students would ideally like. Past studies that have made use of the CLES have found that the instrument is robust and consistently displays high reliability and a consistent factor structure. The CLES has been validated in studies across several countries, including Korea (Kim, Fisher & Fraser, 1999; Lee & Fraser, 2002), the United States (Dryden & Fraser, 1998; Johnson & McClure, 2002) and Australia and Taiwan (Aldridge, Fraser, Taylor & Chen, 2000).

Action research provides teachers with an opportunity to apply the findings of traditional research to their own situations and to adapt theory to practice. It also involves teachers as participants in their own educational process, and helps them to develop a critical and reflective eye for their own instructional practices along with those of their peers (Lederman & Niess, 1997). Yarrow, Millwater and Fraser (1997) explored the use of action research and reflective practices in an attempt to improve the learning environments of primary school classes during preservice teachers' training. The teachers were required to produce a 'case writing' to heighten the importance of their 'voice' and were guided by their daily experiences. According to Yarrow, Millwater and Fraser (1997), action research is collaborative and is achieved through critically examining actions made by the participants themselves, providing a link between theory and practice. The present study sought to use student responses to an actual and a preferred version of the CLES to help them to identify aspects of the constructivist learning environment that they would like to improve.

METHODS, TECHNIQUES OR MODES OF INQUIRY

Large-Scale Data Collection

The CLES was originally developed to assess the perceptions of high school science and mathematics students, but the present study aimed to use it with intermediate and senior phase school mathematics students. When the CLES was first used in countries outside of Australia, such as Taiwan (Aldridge, Taylor, Chen & Fraser, 2000), the USA (Fraser & Dryden, 1996, 1998), Nigeria (Idiris & Fraser 1996) and Korea (Kim, Fisher & Fraser, 1999; Lee & Fraser, 2002), it was found necessary to modify it to ensure its suitability to that country. It was important, therefore, that the CLES underwent a degree of modification to ensure its suitability for learners in South Africa.

Although the medium of instruction in South African schools is English, some terms and phrases within the CLES were unlikely to be understood by the learners. To avoid confusion, the word 'learner' was substituted for 'student'. In addition, changes were made to make the CLES suitable for use in 'mathematics' classes, as opposed to 'science' classes (where it was originally designed to be used). The modified CLES was pilot tested in three classes, each located in schools selected from a rural, semi-rural (township area) and urban area. Six learners from each class were interviewed to check the readability of the items and to ensure that students interpreted each item as intended.

The interviews with students indicated that, when talking about the Critical Voice scale, learners were not happy to ask the teacher about their learning, and this scale was causing a degree of confusion amongst learners. Therefore, it was decided that the Critical Voice scale would be omitted. The final version of the CLES used in this study was composed of four

scales (Personal Relevance, Uncertainty, Shared Control and Student Negotiation) with six items in each.

The modified CLES was administered to a sample of 1864 intermediate (Grades 4 – 6) or senior level (Grades 7 – 9) students in 43 classes. The sample involved 29 teachers in six schools selected from within the Capricorn region of the Limpopo Province of South Africa. From each of the areas, a primary and a secondary school were selected. Four mathematics teachers who were teaching intermediate-phase classes (Grade 4 to Grade 6) were selected from each area, making a total of 12 intermediate-phase mathematics teachers. Two mathematics teachers who were teaching senior-phase classes (Grade 7 to Grade 9) were also selected from each area, making a total of six senior-phase mathematics classes. Every attempt was made to ensure that the sample selected was representative of the classes and schools in the area from which they were drawn.

Case Studies

Of the six schools included in the large sample, two teachers from two of the schools were selected for intervention. The selection of these teachers was based largely on their willingness to be involved in this phase of the study and on the proximity of the school to the researcher. The two schools were located, respectively, two kilometres and 23 kilometres from the researcher's office. From one school, a teacher teaching Grades 5, 6 and 7 (Intermediate and senior phase) was selected while, from the other school, a teacher teaching Grades 6 and 7 (Intermediate and Senior phase) was selected.

Teaching strategies were implemented over a 12-week period to improve the learning environment. During this time, teachers attended a workshop, designed to assist them to learn how to keep and use a teaching journal, which they were encouraged to use as a means of reflection throughout this intervention period. Graphical profiles of students' perceptions of the actual and preferred classroom environment (the information for which was collected during the large scale administration) were used to provide a focus from which reflective practice commenced. Using spiralling cycles of questioning, planning, implementing, collecting data and reflecting through journal writing, as suggested by Yarrow, Millwater and Fraser (1997), teachers developed strategies aimed at improving their learning environments. After each lesson, teachers followed four steps of (1) planning the lesson, (2) implementing the lesson, (3) observing what students are doing and (4) reflecting on the success of the lesson. This information guided the planning of the next lesson and started the cycle again. At each stage, teachers were encouraged to ask themselves questions that would guide their reflections.

During the 12-week intervention phase, observations of the classes of the two case study teachers were used to determine whether they were using their reflections in their classroom practice and to provide encouragement and feedback during the process. One class taught by each teacher was observed at least three times in a month. Also, interviews were held with four students from each class at the beginning, middle and end of the intervention phase to provide more in-depth information regarding their perceptions of the learning environment.

ANALYSES AND RESULTS

Reliability and Validity of the Constructivist Learning Environment

In the first stage of the study, four scales of the original Constructivist Learning Environment Survey (CLES) were administered to 1843 learners in 43 classes. Analyses of these quantitative data were conducted to determine the validity and reliability of the CLES when used in South Africa. A principal components factor analysis with varimax rotation confirmed the *a priori* structure of the instrument comprising 24 items in either the actual or preferred form, with six items in each of the four scales of Personal Relevance, Uncertainty, Shared Control and Student Negotiation. Table 1 shows the factor loadings obtained for the sample of 1864 learners in 43 classrooms in six schools for the actual form of the CLES.

Table 1:
Factor Loadings for a Modified Version of Actual Form of the CLES in South Africa

Item No	Factor Loading			
	Personal Relevance	Uncertainty	Shared Control	Student Negotiation
1	0.35			
2	0.48			
3	0.41			
4	0.49			
5	0.45			
6	–			
7		0.30		
8		0.42		
9		0.32		
10		0.31		
11		0.44		
12		0.39		
13			0.40	
14			0.44	
15			0.46	
16			0.48	
17			0.49	
18			0.36	
19				0.45
20				0.51
21				0.51
22				0.40
23				0.51
34				0.38
% Variance	6.18	4.75	6.65	18.10
Eigenvalue	1.48	10.14	1.60	4.34

Factor loadings smaller than 0.30 have been omitted. The sample consisted of 1864 students in 43 classes in South Africa.

The factor analysis, depicted in Table 1, supports the 24-item four-scale version of the actual form of the CLES. All the items have a loading of at least 0.30 on their *a priori* scale and no other scale, with the exception of Item 6 (whose loading is less than 0.30 on every scale). The percentage of the total variance extracted and the eigenvalue associated with each factor are recorded at the bottom of Table 1. The percentage of variance ranges between 4.75 and 18.10 for the four scales, with the total being 35.68 percent.

The internal consistency reliability (Cronbach alpha coefficient) was calculated to determine the extent to which each item in a scale measured the same construct. Table 2 reports the internal consistency reliability (Cronbach alpha coefficient) of the actual and preferred versions of the CLES for each of the scales for two units of analysis (the individual and the class mean). For the actual version of the CLES, scale reliability estimates range from 0.60 to

Table 2:
Internal Consistency Reliability (Cronbach Alpha Coefficient), Discriminant Validity (Mean Correlation With Other Scales) and Ability to Differentiate Between Classrooms (ANOVA Results) for Two Units of Analysis for the Modified Version of the CLES

Scale	Unit of Analysis	Alpha Reliability		Mean Correlation with other Scales		ANOVA Eta^2
		Actual	Preferred	Actual	Preferred	Actual
Personal Relevance	Individual	0.61	0.56	0.35	0.44	0.23**
	Class Mean	0.88	0.83	0.56	0.76	
Uncertainty	Individual	0.60	0.61	0.40	0.41	0.26**
	Class Mean	0.90	0.93	0.68	0.74	
Shared Control	Individual	0.63	0.78	0.33	0.43	0.20**
	Class Mean	0.90	0.97	0.61	0.75	
Student Negotiation	Individual	0.63	0.75	0.34	0.35	0.15**
	Class Mean	0.91	0.94	0.68	0.62	

** $p<0.01$; The sample consisted of 1864 students in 43 classes in South Africa.
The eta^2 statistic (which is the ratio of 'between' to 'total' sums of squares) represents the proportion of variance explained by class membership.

0.63 using the individual as the unit of analysis, and from 0.88 to 0.91 using the class mean as the unit of analysis. For the preferred version of the CLES, the scale reliability estimates range from 0.56 to 0.75 using the individual as the unit of analysis, and from 0.83 to 0.97 for the class mean as the unit of analysis.

The mean correlation of a scale with the other scales was used as a convenient index of discriminant validity and is reported in Table 2. For scales of the actual form of the CLES, the mean correlation of a scale with the other scales varied between 0.33 and 0.40 with the individual as the unit of analysis and between 0.56 and 0.68 with the class mean as the unit of analysis. For the preferred form of the CLES, the mean correlation of a scale with the other scales varied between 0.35 and 0.44 with the individual as the unit of analysis and between 0.62 and 0.76 with the class mean as the unit of analysis. These values generally can be regarded as small enough to confirm the discriminant validity of raw scores on the CLES, although some values are relatively high at the class level of analysis. This suggests that raw scores on each CLES scale generally measure distinct aspects of the classroom learning

environment. However, the factor analysis attests to the independence of factor scores on the four CLES scales.

An analysis of variance (ANOVA) was used to determine the ability of the actual form of each CLES scale to differentiate between the perceptions of students in different classes. The eta^2 statistics was calculated to provide an estimate of strength of the association between class membership and the dependent variable (CLES scale). The ANOVA results, presented in Table 2, indicate that each scale is able to differentiate significantly between classrooms ($p<0.01$). The amount of variance in scale scores accounted for by classroom membership (i.e. eta^2) range from 0.15 to 0.26 for different scales. These findings suggest that students perceive the learning environments of different mathematics classrooms differently.

Using the CLES to Guide and Monitor Changes to the Learning Environment

The intervention phase aimed to investigate whether teachers were able to make use of feedback information based on students' responses to the CLES to develop and implement action research strategies to improve the environment of their classrooms. In addition, information was sought to determine whether journal writing is an effective tool for encouraging teachers to reflect on their teaching. Teachers used graphical profiles, generated through student responses to the CLES, as a focus for improving their learning environments. At the end of the intervention period, the CLES was readministered to students to determine whether they perceived that teachers had made positive changes to the learning environment.

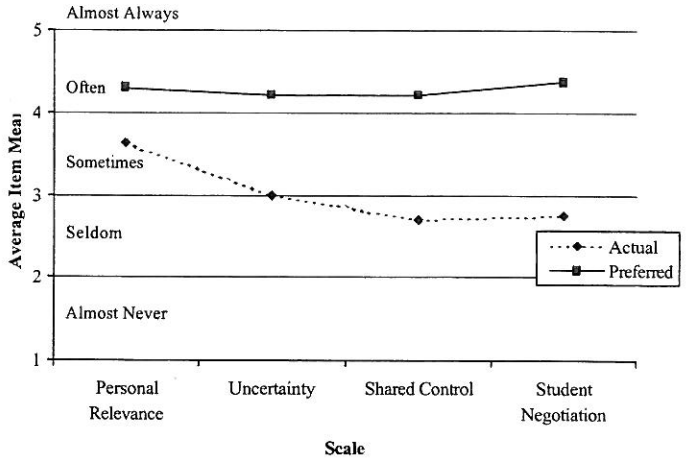

Figure 1:
Average item mean for students' actual and preferred scores on the CLES.

This section describes how one case study teacher used student responses to the CLES to help her to design strategies for improving the learning environment in their classes. The case study involved a female teacher who was teaching intermediate (Grades 4 – 6) mathematics classes in the Limpopo Province of South Africa. Although she taught in a school that has

electricity, it lacked many other resources. She volunteered to be a part of the study because she felt that it would assist her to teach in ways that were more constructivist and student-centred.

The teacher was provided with the results of students' responses to the actual and preferred versions of the CLES in the form of a graphical profile (see Figure 1). These were discussed with the teacher who was optimistic that she would be able to implement more constructivist teaching strategies, and improve her students' perceptions of the learning environment over the 12-week intervention period. The teacher selected a particular dimension, namely, Personal Relevance, of the CLES that she felt was important. Using the items within these dimensions, the teacher designed strategies that would assist her to improve her constructivist teaching practices.

Strategies Used By Teacher to Increase Emphasis on Personal Relevance

This teacher is currently teaching mathematics and science to students from Grade 5 to Grade 7. She is in her fifties and holds a two-year primary teachers' certificate, which was awarded in 1969. She has since studied privately to obtain a further diploma in teaching through distance education. She has been teaching for over 30 years and is still energetic and enthusiastic. She is eager to change from the more teacher-centred methods to which she is accustomed to more student-centred methods. Though nearing retirement, she is dedicated to her job and was keen to be observed by the researcher. This teacher's mathematics class had 46 learners arranged into groups of four or five students.

In attempting to improve the level of Personal Relevance, the teacher decided to: discuss and impress on students the importance of mathematics to their future lives; and make the problems that she presented to students more relevant to their daily lives. The teacher considered that a key aspect of Personal Relevance was the importance of mathematics to the future of the learners. To give learners an appreciation of the role of mathematics in their future, the teacher decided that she would give the learners the task of asking their parents about the role of mathematics in their lives. Learners were then asked to discuss their findings in groups before reporting back to the whole class. In addition, this teacher sought to integrate the mathematics lessons into a language lesson by asking learners to write a composition entitled *The importance of mathematics in our daily life and our future.*

In an attempt to increase the students' perceptions of the level of Personal Relevance, the teacher also made mathematics more related to their daily life. In the past, she had not paid much notice to the types of problems that she presented to students. She was often content to use examples that might have lacked relevance to the learners. To address this, she tried to give students exercises that involved students' surroundings. For example, when teaching measurement, she provided opportunities for the learners to measure distances around buildings and classrooms. She also involved the learners in practical examples, such as measuring their own heights using metre sticks or rulers. When teaching money, addition and subtraction, she decided that she would use shopping lists that included items that students would commonly purchase.

A big step for this teacher was to implement her ideas using group work, something with which she had not had much experience. As a first step, she changed the way in which desks were arranged in her classroom so that students were no longer facing the chalkboard, but were seated in groups of four or five students. She felt that learning would be more

meaningful and more relevant to learners' everyday lives if she could guide them through practical examples and hands-on experiences rather than telling them information. However, the introduction of group work was the most difficult aspect of the intervention period and the teacher experienced numerous problems (e.g. learners tended to talk over each other, and they were much noisier than they had been in the past). It was at this stage of the intervention period that the teacher required the most support from the researcher.

Examining the Success of the Teacher's Strategies

The graphical profile shown in Figure 2 provides the results of the posttest administration of the CLES. It also reports the same information for students' actual and preferred scores as was depicted in Figure 1. These results indicate that students perceived a more favourable learning environment (in terms of the CLES) for all scales on the posttest scores, relative to the pretest. Apparently the strategies employed by the teacher to improve Personal Relevance affected students' perceptions of all four CLES scale. However, also, it seems that the changes that the teacher attempted to make to her learning environment and the use of group work also led to improved levels of Uncertainty, Shared Control and Student Negotiation

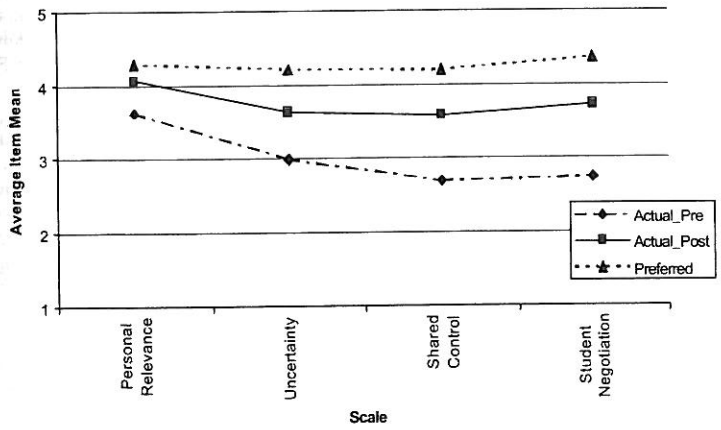

Figure 2:
Average item mean for students' actual pretest, actual posttest and preferred scores on the CLES.

Using Journals as a Tool for Reflection

A further thrust of the study was to explore whether the use of journals was helpful for teachers in their bid to improve the learning environment. Throughout the 12-week intervention period, the teacher was asked to keep a daily journal in which she wrote about and reflected upon strategies that she was implementing in her classrooms. The teacher used the journals to reflect on issues such as: "Today I failed to allow the freedom that would allow my learners to ask me questions freely. I must see to it that I practice having a healthy

classroom atmosphere that allows the learners to express themselves freely." When interviews were conducted with the teacher, she said that the use of journals had helped her to improve her professional skills. The teacher stated: "Writing a journal is like doing lesson preparation in a reflective way because you are writing about what happened, and you are being introspective about all that you did during the lesson." Although the teacher agreed that the use of journals was useful, she complained that it was time consuming. Throughout the intervention period, the teacher required constant support and encouragement from the researcher to make entries into and use the journals. It would appear that, despite the reluctance to write the journals, journal-writing did help to keep the teacher on track and to think about possible solutions.

DISCUSSION AND CONCLUSIONS

A major contribution of the present study was the modification and validation of a questionnaire (the Constructivist Learning Environment Survey, CLES) to monitor the development of constructivist learning environments in intermediate and senior schools in South Africa. Careful modification and pilot testing of the CLES (developed originally in the West) ensured its suitability for mathematics classroom environments in South Africa. Analyses of data collected from 1864 students in 43 classes in six schools supported the CLES's factor structure, internal consistency reliability (Cronbach alpha coefficient), discriminant validity and ability to differentiate between classes. The results are comparable to those of other countries where the CLES has been used, including Taiwan and Australia (Aldridge, Fraser, Taylor & Chen, 2000), Korea (Kim, Fisher & Fraser, 1999; Lee & Fraser, 2002) and the US (Dryden & Fraser, 1998).

Descriptive information related to students' perceptions of the actual and preferred learning environments was provided to each of the teachers who participated in the study. One teacher, who was keen to attempt to improve her students' perceptions of the constructivist orientation of her learning environments, was selected to examine whether the CLES could be used to guide and monitor changes in the learning environment. The teacher selected the Personal Relevance scale and implemented a range of strategies aimed at improving this dimension. Using a journal, the teacher recorded her attempts to improve the degree of constructivism, the problems that were encountered and the strategies that were used to overcome these problems. At the end of this period, the actual version of the CLES was re-administered to students to determine whether changes had taken place. The posttest scores indicated a notable improvement in students' perceptions during the intervention period. It is felt that the dramatic improvement in students' scores on the CLES during the intervention period was due largely to the introduction of small-group work during which students were involved in student-centred activities that encouraged discussion and negotiation.

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