Studies in Educational Evaluation 34 (2008) 118–130

Contents lists available at ScienceDirect

Studies in Educational Evaluation

journal homepage: www.elsevier.com/stueduc

The achievement gap between science classrooms and historic inequalities

Sarah Howie *, Vanessa Scherman

University of Pretoria, Pretoria, South Africa

ABSTRACT

In the past politics deprived many African children (in particular) in South Africa the opportunity of achieving quality education. This was most especially true in subjects such as mathematics and science. In this research the science teacher-level data from Third International Mathematics and Science Study 1999 (TIMSS'99) were analysed with a view to evaluating the politicized gap between what are viewed as well-functioning and provisioned classrooms (predominantly housing White teachers and White or mixed classes in urban areas) and not well-functioning and poorly provisioned classrooms (largely African teachers and African pupils in peri-urban and rural areas). The data are explored in this article to ascertain and gain insight into similarities and differences in classroom conditions, teacher actions and the relationship between these and pupils' achievement in science in South African classrooms. Significant differences in achievement were found between classrooms headed by teachers with different racial profiles, where the pupils' average class science score taught by White teachers was about 300 points more (on a scale with an international mean score of 500 points) than children taught in classrooms by African teachers. Furthermore, the average class science score in rural areas was about 130 points below classes in urban areas. These blatant inequalities contribute to what is believed to be an increasing gap in achievement in science. Whilst these results are not altogether unexpected, there were some interesting results in terms of possible explanatory factors for the gaps in achievement which have ramifications for policymakers.

Introduction

This paper aims to ascertain the extent of the gap existing between classes of different schools regarding classroom conditions, teacher characteristics and teacher actions in South Africa and secondly to determine the extent to which a variation in conditions and teacher actions is related to the achievement in science in South African classrooms. South Africa is described as being both first world and third world in nature and as such this gives rise to differences in conditions and performance nationally.

In the past politics deprived many African children (in particular) in South Africa the opportunity of achieving quality education. This was most especially true in subjects such as mathematics and science where very few African pupils exited school with qualifications in science. The actions of politicians in the mid-1900s, to systemically prevent good quality education for children of the so-called non-White[1] communities, has had a devastating impact, most especially on the mathematics and science education, some 50 years later. Some sense of these actions causing a huge racial divide can be detected in Table 1.

The design and implementation of interventions to restore quality education is currently a priority within South Africa. This has not been without its own controversies (such as the new Curriculum 2005[2] multilingual education, redeployment of teachers and several others). Just as a new dispensation come to power in 1994, the first of the new studies namely, Third International Mathematics and Science Study (TIMSS) was implemented in 1994/1995. This was followed by its repeat study of Grade 8 pupils in 1998/1999. These studies were well-timed and well-placed to provide baseline data to the new democracy and its policymakers, curriculum developers and education officials at all levels.

As more than 80% of the South African TIMSS 1999 sample comprised schools, which are disadvantaged to some extent in terms of human and physical resources, it was critical that an analysis of the data from the science teachers' questionnaire was done *to ascertain the effect of the conditions within these disadvantaged schools' science classrooms on the students' science*

* Corresponding author at: University of Pretoria - Groenkloofcampus, Centre for Evaluation and Assessment, Faculty of Education, AIS Building, Room 30, Pretoria 0002, South Africa. Tel.: +27 12 420 4131.

E-mail address: sarah.howie@up.ac.za (S. Howie).

[1] This term used during the Apartheid era denoted any person of colour as being non-European whilst the term White indicated a person of European descent.

[2] An outcomes-based curriculum introduced post-1994 and intended for full implementation which was fraught with difficulties and had to be overhauled.

0191-491X/$ – see front matter © 2008 Published by Elsevier Ltd.
doi:10.1016/j.stueduc.2008.04.007

Table 1
Comparative education statistics 1989

	White	Indian	Colored	African
Pupil:teacher ratios	17:1	20:1	23:1	38:1
Under-qualified teachers	0%	2%	45%	52%
Per capita expenditure including capital	R3082.00	R2227.01	R1359.78	R764.73
Std 10 (Grade 12) pass rate	96%	93.6%	72.7%	40.7%

Hofmeyer and Buckland (1992, p. 22).

performance as compared to those pupils in classes deemed more 'advantaged'.

More specifically, the research questions that are addressed in this article are

(1) To what extent do the classroom conditions, teachers' characteristics and school resources differ across schools in South Africa?
(2) What is the relationship between classroom conditions, teachers' characteristics and classroom resources and science achievement and how do these differ across schools?

A brief overview of relevant literature on factors influencing science performance is given in the next section, followed by sections on background information on the SA TIMSS 1999 study and conceptual framework for this research. Then the research and analysis methods are described and the research findings presented and discussed.

Classroom-level factors associated with performance in science

Factors affecting performance include time on tasks, homework, teacher knowledge, textbook provision, libraries, teachers' experience and class size. In addition, laboratories are seen as important for effective schooling (Howie, 2005). Taylor, Pressley, and Pearson (2000) argue that the factors that result in effective schools consist of two components namely instructional factors on a classroom-level and organisational factors on a school-level, both of which are equally important.

Furthermore, effective teachers are characterised by excellent classroom management skills, providing balanced instruction and students who are often working in small groups. Teaching style is also of importance, specifically hands-on activities, as well as, technology and integrated learning experiences where the foci are on reasoning and problem-solving abilities (Adam, Brower, Hill, & Marshall, 2000). Also Shavelson and Baxter (1991) believe that hands-on science is of importance and teacher planning should be an integral aspect of instruction. Presentation of content-based lessons, based on well-designed lesson plans with adequate notes and textbooks are of important as well as the use of additional resources along with the textbooks (Rogan & Grayson, 2003). Homework, belief in the efficacy of science, class size, orderly classroom environment, teacher experience and a readiness to teach a range of science topics were also found to be of importance when analysing the TIMSS 1999 data across countries (Martin, Mullis, Gregory, Hoyle, & Shen, 2000).

Finally, Bos (2000) lists possible classroom-level factors that make a difference as being gender, experience, instructional time, class size, teacher beliefs, curriculum content coverage, cooperative learning, homework and resources.

TIMSS-1999 in South Africa

TIMSS 1999, also known as TIMSS-Repeat or TIMSS-R, was a replication study. It followed 4 years after the first TIMSS study in 1995 (for more details on SA participation and the results see Howie, 2001, 2002). This study was designed to provide trends in 8th grade mathematics and science achievement with reference to an international context (Martin, Mullis, Gonzalez, et al., 2000). The South African sample, which was nationally representative and stratified by province, initially included 225 schools to accommodate inter-provincial analysis. However, 194 schools, 190 science teachers and 8147 pupils were ultimately included in the dataset (Howie, 2005).

Achievement data were collected through mathematics and science tests and performance assessment tests. In addition questionnaires were administered at the national and school-level. At school level, based on a review of the school, teacher and student factors shown in previous research to be related to student achievement, questionnaires were developed for the school principal, the mathematics teacher, the science teacher and the student.

Conceptual framework

The conceptual framework for this research is the same as for the larger project, namely TIMSS 1999. Nonetheless, it is highly relevant for the discussion of classroom-level factors that the audience is introduced to the conceptual framework underpinning the research project.

The model shown in Fig. A1 presents the education system in terms of inputs, processes and outputs. A detailed discussion of the framework can be found in Howie (2002) and the reader is encouraged to refer to this source for further details. For the purpose of this article, *teacher characteristics* and *school quality* under *antecedents, curriculum quality, teaching conditions* and *instructional quality* under *practice* are the components of investigation for this research. The variables contained within each of these components are detailed later in the paper.

Research and analysis methods

As stated earlier, the research questions guiding this paper refer to how the classroom conditions, teachers' characteristics and school resources differ across schools in South Africa and how these variables relate to science achievement across schools.

The variables were identified from the teacher questionnaire with a few school-level variables (identified from the school questionnaire) such as enrolment for the school, per grade and average class size; limitations to education due to shortages of general resources and of science specific resources; and the location of the school.

Identification of advantaged and disadvantaged groups

The school-level variables were used to evaluate the school and classroom data and to classify schools as being more or less advantaged. The measure of *shortages of general resources* (scale of 0–15) was computed after schools had indicated that there were no shortages, a little shortage, some shortages or a lot of shortages. These general resources included heating and lighting, instructional space, budget for supplies, school buildings and instructional materials. A high score indicated a lack of general resources. Likewise similar measure (scale of 0–18) was calculated for the *science specific resources*. A high score on this measure indicated a lack of science specific resources. Principals indicated whether or not there were shortages of laboratory equipment, computer software, computer hardware, calculators, audio-visuals and library materials.