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Analysis of South African postgraduate degrees in science education: 1930-2000

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Introduction

Having celebrated 1998 as a Year of Science and Technology, the South African government is becoming increasingly aware—consistent with worldwide trends—of the need to promote science and technology in the country. As is clear from the government's*White Paper on Science and Technology*, the increasing prominence of science and technology in the public arena is motivated by a number of reasons including, for example, the need for citizens to be able to use scientific and technological information to make more meaningful decisions in their daily lives and the realisation that science and technology (and consequently scientists, engineers and technicians) play an important role in the economic well-being of a country (Department of Arts, Culture, Science and Technology, 1996). It is widely accepted that South Africa requires vigorous and sustained economic growth in order to meaningfully address the many socio-economic challenges facing the country. However, in South Africa the number of scientists, engineers and technicians per 100 000 of the general population is very low compared to more developed countries such as, for example, Australia (Foundation for Research Development [FRD], 1996). In addition, contemporary modes of production increasingly require a workforce more knowledgeable in science and technology (Lewin, 1995). However, student enrolments at tertiary educational institutions are decreasing in science- and engineering-related fields of study (FRD, 1996), and pass rates in grade 12 school leaving examinations in a critical school subject like Physical Science have generally been low. In fact, comparatively few students take these two subjects at senior secondary level. Moreover, South African students faired very poorly in comparison to students from other countries in the recent Third International Mathematics and Science Study (Howie & Hughes, 1998).

From the above, it is clear that science education in South Africa faces a number of important challenges. The important role of research in helping to address these challenges must be regarded as incontestable, and it is therefore appropriate to examine the direction science education research in South Africa has taken in the past and to highlight key features of this country's science education research effort. Such an examination will potentially inform future directions and emphases that South African science education may wish to take and have. An analysis of the postgraduate degrees in science education awarded by South African universities is a first step in carrying out this examination, and such an analysis has never been undertaken to date. The period under review in this study commences with the year in which the first science education–related higher degree was awarded in South Africa, and ends with the latest year for which reliable and accurate graduation data are currently available. The analysis therefore includes the 70-odd years between 1930 and 2000.

The objectives of the study are to systematically describe trends in the award of theses (i.e., doctoral degrees [i.e., PhD, DEd, DPhil, etc.]) and dissertations (i.e., Masters degrees [MEd,

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MSc, MPhil, etc.]) in science education completed at South African universities during this period, and to describe and analyse the topics addressed by these higher degrees.

Methodology

A postgraduate degree in "science education" is here defined as any masters or Doctoral degree that examines aspects related to at least one of the following themes: a) teaching and learning of the natural sciences; b) teacher development and training in the natural sciences; c) policy issues related to the provision of a) and b) above; d) methodological issues related to a) to c) above; and e) public understanding of science. In keeping with tradition, the teaching and learning of mathematics was excluded from the definition of science education.

The research methodology employed involved systematically identifying science education–related postgraduate degrees completed at South African universities, and assigning keywords (or content descriptors) that adequately describe the topics addressed by these degrees. In order to identify such works, appropriate databases such as *Nexus* (a database of current and completed research projects maintained by the National Research Foundation), *Sabinet* (a commercial database of numerous South African publication types), and the *Union Catalogue of Theses and Dissertations* (a database of South African higher degrees compiled by the Ferdinand Postma Library at the Potchefstroom University for Christian Higher Education) were interrogated. In addition, annual research reports of the Education and Science Faculties at South Africa's 20 universities were searched.

As a number of inconsistencies and omissions were detected amongst the databases used, details of the degrees were verified by requesting all university libraries in South Africa to independently obtain information about their holdings of science education-related thesis and dissertations completed at their institution, and to forward these details to me. Inconsistencies were then resolved by referring to the title page of the original. The sex of the authors was determined from the authors' full name listed in the database(s) or on the title page of the thesis or dissertation. Unfamiliar first names were referred to appropriate colleagues. The language in which the higher degree was written (i.e., English or Afrikaans) was determined from the title. Afrikaans titles were translated in cases where English titles were not already supplied by the database(s). The abstract of the postgraduate degrees was obtained either from the databases or from the original work itself (where available). Titles and abstracts were then scrutinised by myself in order to assign keywords to each of the higher degrees; the abstracts in Afrikaans only were ignored. In summary, the title and the abstract (either the original or an abridged one supplied by *Nexus*) were used to assign keywords in 79% of higher degrees, and in the remaining 21% only the title was used.

Results

The analysis of postgraduate degrees in science education is based on 474 theses and dissertations awarded in South Africa between 1930 and 2000. Nineteen out of South Africa's 20 universities awarded higher degrees in science education during this period, with the University of Venda for Science and Technology being the only exception. As far as could be established, the first Masters degree was awarded in 1930 at the University of the Witwatersrand, and the first doctorate was awarded in 1939 at the Potchefstroom University for Christian Higher Education. Twenty-three percent of postgraduate degrees identified are doctorates and 77% are Masters degrees. The vast majority (77%) of Masters degrees were awarded in Education (i.e., MEd), with 16% being awarded in Science (i.e., MSc). Other types of degrees (e.g., MA, MSocSci, etc.) made up the remaining Masters degrees. Thirty-six percent of higher degrees were completed by females. Results of more fine-grained,

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quantitative analyses are presented first, with those of the qualitative analyses described thereafter.

Quantitative analyses

In comparison to earlier years, a dramatic increase in the award of higher degrees is evident in the last decade (Figure 1), with 59% of all postgraduate degrees having been awarded between 1991 and 2000. Although both the number of Masters and doctoral degrees has increased steadily over the last 30 years, the great increase in the number of higher degrees awarded over the last 10 years is mainly due to the tripling of the award of Masters degrees between the 1980s and the 1990s (Figure 2). While most earlier higher degrees were completed by males, the number of postgraduate degrees completed in science education by either sex in the last decade is almost equal (Figure 3). Not unexpectedly, there is a statistically significant difference in the number of degrees completed by males and females

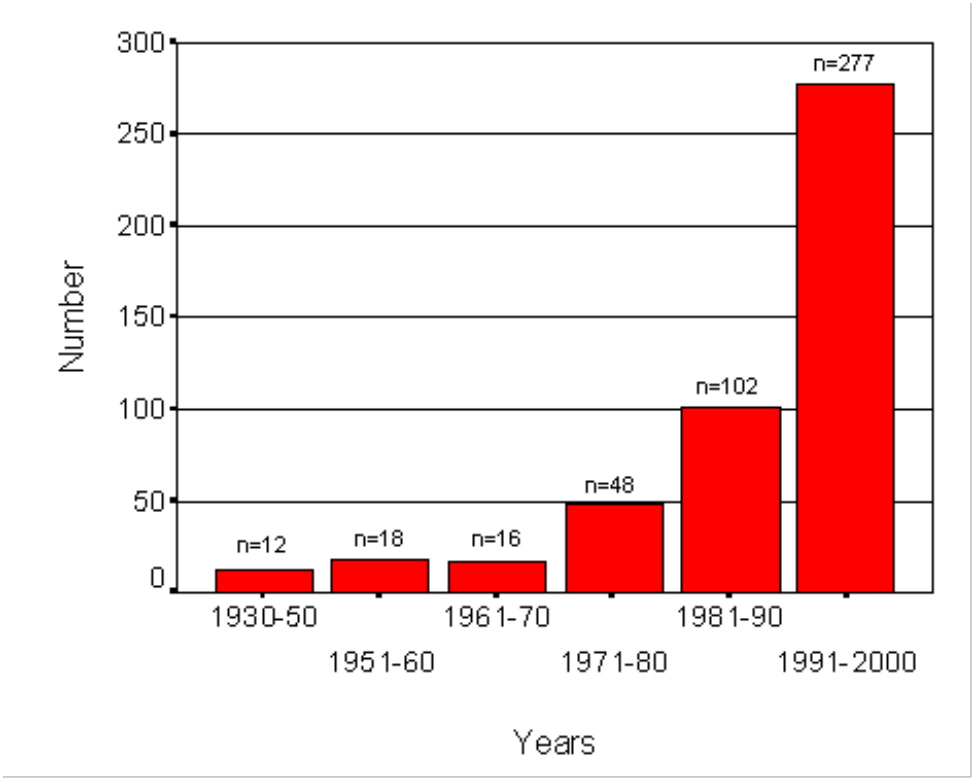

Figure 1. Number of postgraduate degrees in science education awarded in South Africa (*N* = 474)

over the entire 70-year period (χ^2 = 6.91, d.f. = 1, $p < 0.01$), but the association between sex and the number of degrees awarded is not significant for the years 1991 to 2000 (χ^2 = 1.24, d.f. = 1, $p > 0.05$). In general, however, males have completed a significantly higher proportion of doctoral degrees than females (Fisher's Exact Test [one-tailed], $p < 0.01$) but, again, not in the last decade (Fisher's Exact Test [one-tailed], $p > 0.05$). Although only 40% of higher degrees awarded in science education between 1930 and 1950 were written in Afrikaans, the proportion of degrees written in that language increased in subsequent years and ranged between 63% and 94%for the years 1951 and 1980, respectively. Since then, the proportion of postgraduate degrees written in English has increased steadily, and in the last decade more than 80% of theses and dissertations were written in English.

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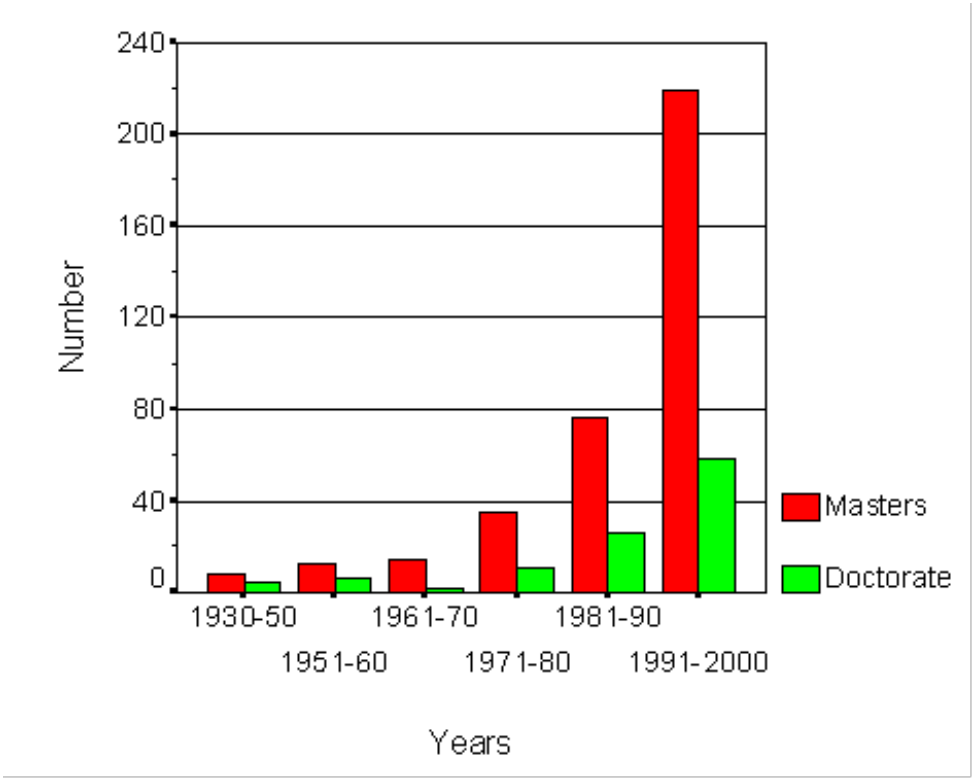

Figure 2. Number of postgraduate degrees in science education awarded in South Africa by level of degree

As racially segregated universities were established under Apartheid in the late 1960s and early 1970s, it is of interest to examine trends in the award of higher degrees in science education at these so-called historically disadvantaged institutions (HDIs). Since the first higher degree in science education at an HDI was awarded at the University of the Western Cape in 1970 (a Masters degree; the first doctorate at an HDI was awarded in 1972 at the same university to the same person), a total of 73 Masters and doctoral degrees have been awarded at HDIs. These degrees represent 15% of all science education degrees awarded in South Africa or—put differently—17% of all higher degrees awarded since 1970. If degrees awarded at the University of the Western Cape (reserved for 'Coloureds') and at the University of Durban-Westville (reserved for Indians) are excluded, only 24 higher degrees—or 5% of all degrees in science education—have been awarded at the seven historically *African* universities.

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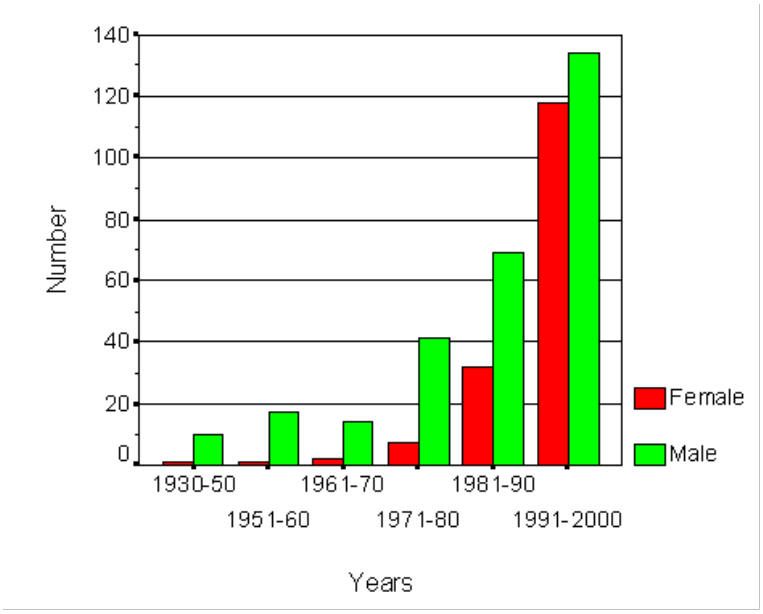

Figure 3. Number of postgraduate degrees in science education awarded in South Africa by sex

Qualitative analyses

The qualitative analyses of the 474 higher degrees in science education are based on the relative frequency of occurrence of appropriate and relevant keywords calculated per 100 theses and dissertations. The qualitative analysis takes two forms. First, in order to obtain a sense of what kind of topics these higher degrees have addressed, and whether there has been a change of these topics over time, the relative frequency of occurrence of 40 keywords in South African higher degrees in science education for the periods 1930-80 (n = 94), 1981-90 (n = 102), and 1991-2000 (n = 277) were calculated (Table 1). In order to have some frame of reference, the keywords used here are a subset of those employed by White (in press) in his analysis of the worldwide revolution in science teaching. Table 1 shows the popularity of keywords and the changes in pattern over the three periods under discussion. The largest category contains keywords that have increased in their frequency, followed by keywords whose relative frequency has peaked during 1981-1990. Keywords that have maintained their relative popularity over time are however small in number (Table 1). Noteworthy is the large

Table 1. Relative frequency of occurrence of selected keywords per 100 postgraduate degrees (cf. White, in press)

	1930-80	**1981-90**	**1991-2000**
Total number of degrees	94	102	277
Increased			
action research	0.0	1.0	1.9

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attitud*	7.4	9.6	17.1
classroom(s)	6.3	11.5	19.3
constructivist or constructivism	0.0	4.8	5.2
cooperative learning	0.0	1.0	1.5
creativity	0.0	0.0	0.4
critical thinking	0.0	1.0	1.9
curricul*	13.7	14.4	26.8
interview*	3.2	16.3	25.7
learning strategies	0.0	0.0	3.0
metacognition	0.0	0.0	1.1
misconceptions	2.1	8.7	13.4
peer teaching or tutoring	0.0	0.0	0.7
prior knowledge or learning	0.0	1.0	2.2
problem solving	0.0	1.0	3.0
questioning	0.0	0.0	0.4
science technology society	0.0	0.0	3.0
scientific literacy	0.0	1.9	2.6
society	2.1	1.9	5.6
teacher(s)	26.3	35.6	52.0
technology	0.0	3.8	10.8
Maintained			
assessment	6.3	3.8	5.9
IQ or intelligence	0.0	1.0	1.1

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laboratory	7.4	4.8	7.1
motiv*	2.1	0.0	3.7
reflection	0.0	2.9	3.0
values	3.2	0.0	5.2
Peaked			
ability or abilities	6.3	11.5	9.3
analogy or analogies	0.0	6.7	0.4
comput*	0.0	6.7	4.5
conceptions	0.0	8.7	3.0
epistemolog*	0.0	1.9	0.0
informal learning	0.0	1.0	0.4
inquiry	0.0	2.9	1.1
mastery	0.0	1.9	0.4
metaphor*	0.0	1.0	0.0
museum(s)	1.1	0.0	0.0
Piaget*	1.1	2.9	0.7
sex or gender	1.1	2.9	1.5

* As in White (in press), asterisks indicate the inclusion of words that are an extension of the root (e.g., interview* includes interviews, interviewer, interviewed, etc.)

frequency of a number of related keyword clusters in the increasing category, that is *classroom(s)*, *teacher(s)*, *interview** and*constructivist / constructivism*; *curricul** and *misconceptions*; and *scientific literacy*, *society*, and *technology* (Table 1).

The second qualitative analysis examines the relative frequency of occurrence of terms describing the research subjects and institutions, the school subjects researched, and the research style between 1930 and 2000 (Table 2). Results show that much of postgraduate research in science education in South Africa is focussed on the secondary education level

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and, in particular, on the senior secondary phase. Biology is consistently a favourite school subject for higher degree research, and interest in the teaching and learning of Physical Science is surprisingly waning. The tertiary level is an increasingly popular site for science education research (particularly universities and colleges), where attention is mainly focussed on first-year students. Noteworthy is the increasing frequency of teachers (both at pre- and in-

Table 2. Relative frequency of occurrence of selected keywords related to research subjects, institutions, school subjects and research styles per 100 postgraduate degrees

	1930-80	**1981-90**	**1991-2000**
Total number of higher degrees	94	102	277
Research subjects			
Pre-school	0.0	0.0	0.7
Primary level	4.2	7.7	5.2
Secondary level	32.6	42.3	27.9
Junior secondary	7.4	9.6	6.3
Senior secondary	18.9	26.9	17.5
Tertiary level	4.2	12.5	13.4
1st year	6.3	6.7	7.8
2nd year	0.0	0.0	2.2
3rd year	1.1	1.9	1.5
Pre-service/student teacher(s)	4.2	6.7	10.4
In-service	1.1	4.8	8.6
Subject/Curriculum adviser	0.0	2.9	1.9
Lecturer(s)	4.2	4.8	7.1
School subjects			
Agricultural Science	0.0	0.0	1.5

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Biology	30.5	35.6	32.3
General Science	3.2	5.8	4.1
Physical Science	27.4	26.0	18.6
Institutions			
University(ies)	15.8	13.5	16.4
College(s)	2.1	9.6	11.2
Technikon(s)[a]	0.0	1.9	2.2
Research style			
Qualitative	1.1	3.8	11.2
Quantitative	3.2	10.6	10.4
Questionnaire(s)	8.4	21.2	26.8
Questionnaires and interview*	3.1	6.7	10.8

a South African technikons are tertiary educational institutions were the emphasis in teaching and research is placed more on the practical, rather than the theoretical, aspects of a variety of disciplines. Technikons are widely regarded as almost equivalent in status to a university.

service level) and lecturers as research subjects (Table 2). The quantitative research style continues to be popular, but the frequency of studies employing a qualitative research style is increasing. Postgraduate students increasingly use questionnaires in their research, and the combined use of questionnaires and interviews is rising.

Discussion

The purpose of this study is to describe and analyse trends in South African science education research, as revealed by the kind of research postgraduate students have undertaken. The study is the first to describe such trends based on a systematic and comprehensive identification of higher degrees awarded in science education at South African universities, and therefore also contributes to the history of science education in this country. Arguably the most unexpected finding of this study is the extent to which postgraduate work in science education was being carried out in South Africa in the early and middle years of the previous century. The discipline of science education is regarded as having its longest and best-established tradition in the United Kingdom and in the United

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States, where the earliest doctoral degrees in science education were apparently conferred in the 1930s at Teachers College, Columbia University (Jacobsen, 1980; cited in Nentwig, Frey, Klopfer & Layton, 1983). The first award of a doctorate in science education in South Africa also occurred during this period, and 23 doctorates had already been awarded in South Africa by 1980 (Figure 2). In the light of this and the fact that in some European and Scandinavian countries such as, for example, France and Finland, the first doctorates in science education were only awarded in the late 1970s and early 1980s, the early record of postgraduate degrees in South Africa suggests that science education as a discipline is comparatively well established in this country. The high percentage of postgraduate degrees completed in the last decade certainly attests to the current vibrancy of the discipline.

While the surge in higher degrees in science education over the last ten years is obviously to be welcomed, the likely causes of that surge are worth speculating about. At least three possible reasons come to mind. First, the increasing availability of coursework Masters degrees which are, in research terms, less demanding then Masters degrees by research only; second, the establishment of the—as it was then called—*Southern African Association for Research in Mathematics and Science Education* in 1992; and, third, the commencement in the same year of a programme by the Foundation of Research Development—pre-cursor to the current National Research Foundation—established specifically to fund research in science, engineering, and technology education. Although cause and effect are hard to establish in this instance, it is not unreasonable to conclude that the latter two initiatives probably had a major impact on the output of postgraduate degrees in science education over the last few years.

What is a particularly welcome feature of the dramatic increase in postgraduate science education research activity in the last decade is the fact that neither the number of degrees completed nor the type of degree is associated with a particular sex. This indicates that gender equity certainly appears to be a reality in South Africa as far as science education *research* is concerned. Characteristics of postgraduate degrees with respect to the language used in the writing of higher degrees in science education in South Africa follow anticipated trends, and offer no new insights. The fact that only 5% of *all* postgraduate degrees awarded in science education in South Africa originated at historically African universities is a sad indication of the ‘success’ of previous Apartheid policies. Given the fact that the historically African universities are situated precisely in those rural, educationally under-resourced environments whose teachers and learners would benefit from the expertise of science educators and science education research at such institutions, it makes the establishment and functioning of vibrant, active, and appropriately responsive science education departments at such institutions essential.

While the quantitative analyses of postgraduate degrees in science education awarded in South Africa yield useful information about more general features of the discipline and its relationship to the tertiary education system, the qualitative analyses of these degrees provide more insight into what kind of issues, subjects, and research styles were employed. Although the use of subjectively selected keywords in such qualitative analyses is not unproblematic (see, for example, White, in press), the use of keywords is nevertheless useful. The related clusters of keywords in the increasing category (Table 1) suggest a growth in interest about the dynamics of teaching and learning, the learning of particular content, and the wider applicability to and use of science in broader social settings other than just the school. Keywords that have maintained their frequency (e.g., *assessment*, *laboratory*, and motivation-related issues) appear to signal a continued interest in traditional concerns with respect to the teaching and learning of science. Keywords in the peaked category indicate that topics such as, for example, computers in teaching and learning as well as conceptions are of waning interest (Table 1). The relative

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frequency of keywords thus indicates that South African science education is largely in line with worldwide trends in the discipline (cf. White, in press).

Frequencies of keywords related to research subjects, institutions, school subjects, and research styles clearly show that science education research conducted by postgraduate students in South African is largely focussed on the four years spanning the senior secondary phase and the first year of tertiary study. Given the country's educational history and concern with poor matriculation results in science, this is not surprising. What is, however, counter-intuitive is the greater popularity of Biology compared to Physical Science as a research focus, as the performance of learners in the latter school subject is of much more concern that learners' performance in the former subject. Perhaps it is the fact that more learners take Biology than Physical Science in the senior secondary phase that makes Biology a more common focus of postgraduate research. A further noteworthy trend is that although postgraduate students increasingly use questionnaires in their research, the frequency of a combined use of quantitative/qualitative approaches to educational research—as evidenced by the use of questionnaires *and* interviews—is rising. This indicates an increasing use of a more multi-faceted approach to examining teaching and learning in science education in South Africa, and is in line with general trends in the discipline.

Future challenges and opportunities in postgraduate science education research in South Africa lie in the diversification of research foci from the secondary/tertiary interface. Other, perhaps equally important and possibly fruitful, research foci suggested by analyses conducted in this study include the pre- and inservice training of science teachers, science teaching and learning at the primary or earlier level, and science education at technikons. While the analysis of research conducted by students for postgraduate degrees is an important first step in an attempt to identify the characteristics of South African science education research, postgraduate degrees alone are unlikely to be a sufficiently reliable indicator of the issues the science education research community in South Africa addresses and what methods it employs in the process. The present study will therefore need to be expanded to include other forms of research outputs such as journal articles, books, chapters in books, and conference proceedings. As such, the present research forms part of an ongoing, more general, first study of its kind that attempts to analyse and identify the key features of South African research in science education, and thus chart new frontiers for educational research in the natural sciences in this country.

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