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ABSTRACT

Given the widely accepted need for scientifically literate individuals and the paucity of relevant data on scientific literacy and formal education in South Africa, it is desirable to assess and to provide baseline data on the ability of the secondary education system to generate scientifically literate matriculants. Reported here are the results of a survey based on the "Test of Basic Scientific Literacy" incorporating selected literacy goals recommended by the American Association for the Advancement of Science. The survey investigated levels of scientific literacy of 4,223 first-time entering university and technikon students, registered in a variety of disciplines at the five principal tertiary educational institutions in the Western Cape. Scientific literacy was examined with respect to population group, gender and variables related to secondary and tertiary education. (Contains 34 endnotes.) (Author)

Scientific Literacy of Selected South African Matriculants Entering Tertiary Education: A Baseline Survey

by

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Scientific literacy of selected South African matriculants entering tertiary education: a baseline survey

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Given the widely accepted need for scientifically literate individuals and the paucity of relevant data on scientific literacy and formal education in South Africa, it is desirable to assess and to provide baseline data on the ability of the secondary education system to generate scientifically literate matriculants. Reported here are the results of a survey based on the *Test of Basic Scientific Literacy* incorporating selected literacy goals recommended by the American Association for the Advancement of Science. The survey investigated levels of scientific literacy of 4223 first-time entering university and technikon students, registered in a variety of disciplines at the five principal tertiary educational institutions in the Western Cape. Scientific literacy was examined with respect to population group, gender and variables related to secondary and tertiary education.

Scientific literacy, according to one definition, 'stands for what the general public ought to know about science',[1] and 'commonly implies an appreciation of the nature, aims, and general limitations of science, coupled with some understanding of the more important scientific ideas'.[2] The term is usually regarded as being synonymous with 'public understanding of science',[1] and although the concept is for various reasons often regarded as controversial,[3] the notion of scientific literacy is now commonly acknowledged to consist of three dimensions: an understanding of the norms and methods of science, an understanding of key scientific terms and concepts, and an appreciation of the impact of science and technology on society.[3,4] In an increasingly science-based and technological world, it is widely accepted that a certain minimum level of understanding of science has become a prerequisite for effective citizenship (see references cited in Laugksch[5]). Furthermore, there is growing recognition in the industrialized world that scientific literacy is a crucial component of long-term economic growth (see, for example, Bloch,[6] Hurd,[7] Walberg[8]). The development of a scientifically literate citizenry is therefore considered to be a *sine qua non* for South Africa's economic prosperity and social progress.[5,9]

Various national and cross-national surveys have shown that a large proportion of adults in the United States (see, for example, Miller[10,11]) and Britain (see, for example Durant *et al.*[12] and Lucas[13–15]) has a very limited knowledge and understanding of science. In South Africa, where a survey of the scientific literacy of a demographically representative sample of the adult public was undertaken for the first time in 1995, the situation is no different.[16] Moreover, South Africans have ranked low in international comparisons of scientific literacy, and significant differences were found between the responses of various population groups.[16]

In general, these national and cross-national surveys have shown that an individual's understanding of the various dimensions of scientific literacy is influenced by a number of factors, including age, gender and social class (see, for example, Durant *et al.*[12]). However, the most important influence on scientific literacy was consistently shown to be education.[12,16–21]

With the exception of Glover[22] and Pouris,[23] published research on the relationship between education and scientific literacy in South Africa has been limited exclusively to investigating the promotion of scientific literacy of secondary school pupils through informal, as opposed to non-formal or formal, science teaching.[5] We are aware of only one local investigation of scientific literacy with respect to formal education, namely Glover's,[22] who studied science teachers in the former Ciskei and Transkei. Pouris[23] conducted a literacy survey among a cross-section of South African teenagers and reported that white teenagers perform better than white adults, but the survey was not related to any specific aspect of formal education.

Given the paucity of relevant data on scientific literacy and formal education in South Africa, it is important to assess, and to provide baseline data on, the ability of the education system to generate scientifically literate matriculants. Such an initial assessment, conducted by means of a survey in early 1994, is reported here. The purpose of this survey was twofold. First, to examine levels of scientific literacy of first-time entering university and technikon students with respect to population group and other aspects of the students' backgrounds, as well as with respect to factors related to secondary and tertiary education. Second, to identify predictors of scientific literacy, that is, factors under the direct influence of educators that are strongly associated with the level of scientific literacy of matriculants. Results of the first objective of the survey only are reported in this paper.

Methodology

For the purpose of assessment, we examined the scientific literacy of the 'products' of the education system, that is, school-leavers with a matriculation pass. For a number of reasons, the investigation was limited to matriculants at the secondary/tertiary education interface in the Western Cape. First, it is easier to test students at tertiary educational institutions than at a large number of high-schools. Second, and more important, students at tertiary educational institutions represent a self-selected group of 'successful' matriculants. It is, therefore, reasonable to believe that this latter group is more likely to exhibit successful outcomes of secondary education, such as being scientifically literate, than 'less successful' matriculants who do not enter tertiary education. Third, although the Western Cape accommodated approximately only 9 % of the total population in 1994,[24] a disproportionately large number of students were enrolled in its universities and technikons. For example, in 1991, the universities of Cape Town, Stellenbosch and the Western Cape, and the

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Cape and Peninsula technikons, provided 24 % and 23 % of South Africa's residential university and technikon places, respectively.[25]

The survey questionnaire

The survey questionnaire consisted of two sections (Appendix G of Laugksch[5]). Section A sought self-reported retrospective personal data in a number of different areas (for instance, demographic, educational, socioeconomic), and the following factors in the students' background were used in the analysis reported on in this paper. Matric result is on a six-point scale ranging from A (80–100 %) to F (33–39 %), and relates to the symbol of the overall result of the school-leaving examinations ('matric') at the end of school year 12. The number of science subjects relates to how many subjects were taken in matric; three is the maximum allowable in terms of the examination regulations. Science subject combination identifies each student's mix of subjects out of the five natural science subjects widely taken in senior secondary school in South Africa: Agricultural Science, Biology, Geography, Physical Science, and Physiology. The nine black languages spoken in South Africa (Ndebele, Northern/Southern Sotho, Swazi, Tsonga, Tswana, Venda, Xhosa, and Zulu)[26] were used together with information specifying the then racially-based departments of education in which students had completed their matric in order to derive the population group of each student. This approach was considered to be reliable except in the case of African students whose home language was English and who attended schools under the control of examining authorities other than the former Department of Education and Training and the Transkei Department of Education. Experience of the then-current school situation in the Western Cape led us to conclude that the number of such cases was very small, and that such possible misclassifications have not significantly influenced the results of this survey.

Students were classified as scientifically literate on the basis of completing the *Test of Basic Scientific Literacy* (TBSL), which consists of 110 test-items with a 'True-False-Don't Know' item format[27] and which formed section B of the survey questionnaire.[5] This test is based on selected chapters of the 1989 American Association for the Advancement of Science overview report on literacy goals in science, mathematics and technology, entitled *Project 2061 — Science for All Americans.*[28] This report identifies the knowledge, skills and attitudes that all students should possess, as a consequence of their total school experience, in order to be regarded as scientifically literate. The TBSL consists of three separate subtests, each corresponding to Miller's[4] three constitutive dimensions of scientific literacy: the Nature of Science Subtest (NSST: 22 test-items), the Science Content Knowledge Subtest (SCKST: 72 test-items), and the Impact of Science and Technology on Society Subtest (ISTSST: 16 test-items). The test was marked dichotomously, with one mark being awarded per question for a correct answer, and zero for a wrong one. A 'Don't know' response was considered a wrong answer. No negative marking was used. In order to be classified as scientifically literate, students needed to obtain at least 13 out of 22, 45 out of 72, and 10 out of 16, on the corresponding subtests of the TBSL, respectively. Characteristic features of this test with respect to validity, reliability, and derivation of the performance standards have been reported elsewhere.[27] Selected examples of the test-items used in the TBSL are given in the Appendix.

The survey sample

At the beginning of the 1994 academic year, the survey questionnaire was administered by ourselves during a normal 45-minute lecture period to 6801 first-year students at the Cape and Peninsula technikons, and at the universities of Cape Town, Stellenbosch and the Western Cape. These students had registered for 31 first-year courses in disciplines broadly divided into areas related to engineering, natural sciences (both the life and the physical sciences), commerce and management, and the human sciences, using the categories of File.[25] At each of the five institutions, disciplines were selected in decreasing order of their relative numerical contribution to that institution's overall first-time entering student population in 1993, until approximately 70–80 % of the overall first-time entering student population was accounted for. First-year courses in each discipline were, in turn, selected on the basis of being considered representative of each discipline's first-time entering student population with respect to gender and population group. (Given the great extent to which a student's population group would be expected to have shaped and dominated his or her schooling and educational experiences in South Africa, population group has to be taken into consideration in any analysis of South African educational data in order not to lose information in the aggregation of such data.)

The sample, on which the results reported on here are based, consisted of 4223 students at the three universities and two technikons who entered tertiary education for the first time in 1994, who completed their matriculation exam either in 1992 or in 1993 in South Africa, who in 1994 were younger than 24 years of age, and had left fewer than 39 of the 110 TBSL test-items unanswered. This sample represents 28 % of all registered first-time entering students at the five institutions, and 34 % of first-time entering students registered in the natural sciences and engineering faculties. The majority of students were registered for courses in Commerce and Management (39 %), while 18 %, 28%, and 13 % of students were registered for courses in the Human Sciences, Natural Sciences, and Engineering, respectively. Only 2 % of the sample did not fall into any of the above broad areas of subject specialization. African, coloured (mixed race), Indian and white students comprised 14 %, 26 %, 2 %, and 59 % of the sample, respectively; 42 % of students were black; 52 % of the sample was male. Owing to the particular sampling strategy used, the main areas of subject specialization were not examined in equal proportions at every institution, and the sample also does not consist of equal proportions of students of different population groups in the four areas of subject specialization. This feature of the sample limits the meaningful comparisons of scientific literacy that can be justifiably made.

The sample is representative of the total student population with respect to gender, but African and white students are under- and over-represented, respectively (R.C.L., unpubl. data). The sample slightly favours students in the Natural Sciences and Engineering at the expense of those in the Human Sciences. Overall, the sample is not necessarily representative with respect to each permutation of the three variables related to institution, subject specialization and population group. Nevertheless, sample sizes for students by most population groups and subject specialization are substantial (Table 1).

Analyses

By 'level' of scientific literacy is meant the percentage of scientifically literate students observed among any relevant total number (all students, male students, female students, etc.). For any given attribute (e.g. gender), individuals within each of c-attribute categories (e.g. males and females, $c = 2$) were used to construct $2 \times c$ contingency tables, which were then analysed by

Table 1. The percentage of scientifically literate matriculants by area of subject specialization and population group. In each case the sample size is given in brackets.

Area of subject specialization	African	Coloured	Indian	White	Total
Human Sciences	5 (218)	16 (171)	— (7)	41 (351)	25 (747)
Commerce and Management	9 (147)	20 (386)	45 (20)	39 (1089)	32 (1642)
Natural Sciences	19 (162)	38 (381)	62 (26)	56 (597)	45 (1166)
Engineering	17 (35)	35 (109)	73 (11)	58 (400)	51 (555)
Other areas	0 (32)	17 (42)	— (3)	25 (28)	13 (105)
Overall	10 (595)	27 (1091)	55 (67)	46 (2470)	36 (4223)

conventional procedures and appropriate statistical techniques recommended by, for example, Everitt.[29]

Results and discussion

The overall level of scientific literacy of matriculants entering the five principal tertiary educational institutions in the Western Cape for the first time was 36 %.

Overall matric result. The performance of students in terms of matric results was as anticipated: students with the highest aggregate — an 'A' — also displayed the highest level of scientific literacy (68 %), followed by those with a 'B' (51 %), 'C' (34 %) and 'D' (20 %) aggregate. Only 10 % of students with an 'E', 'F' or 'G' matric result were classed as scientifically literate. The general relationship between scientific literacy and matric aggregate was exhibited by each population group (R.C.L., unpubl. data).

University and technikon students. Approximately one in four technikon students (26 %) and approximately two in five university students (42 %) were classed as scientifically literate. The literacy level of university students was significantly higher than that of technikon students (Fisher's exact test – one-tailed, $P < 0.00001$). This difference reflected the students' respective matric results. Half of first-time entering white students at technikons obtained a 'D', 'E', or 'F' in matric, compared with only 8 % of their counterparts at universities. This is a significantly higher proportion (Fisher's exact test – one-tailed, $P < 0.00001$). [The comparison of student profiles of matric results is restricted to white students in order to avoid the debate on whether matric result is indeed a reliable indicator of academic potential for black students in the light of educational disparities that have been created as a result of apartheid policies (see references cited in, for example, Bokhorst, Foster, and Lea.[30])] There is thus some indirect evidence that students at technikons are likely to be of lower general academic ability than students at universities.

Population group and subject specialization. There were significant differences in the scientific literacy of students belonging to different population groups ($\chi^2 = 329$, d.f. = 3, $P < 0.001$): approximately one in two white and Indian students counted as scientifically literate, whereas about one in four coloured, and only one in ten African students were so classified (Table 1). [The measure of Indian students is based on a much smaller sample than that of other population groups (Table 1), and the high level of scientific literacy of this group therefore needs to be interpreted with caution.]

Differences in the level of scientific literacy between African ($\chi^2 = 2.02$, $P > 0.05$), coloured ($\chi^2 = 0.86$, $P > 0.05$), and white ($\chi^2 = 0.57$, $P > 0.05$) students in the Human Sciences and Commerce and Management (Table 1) were not statistically significant. (For Indian students such a comparison was not possible because of the small sample size.) Similarly, there were no significant differences in literacy levels between African ($\chi^2 = 0.12$, $P > 0.05$), coloured ($\chi^2 = 0.51$, $P > 0.05$), Indian ($\chi^2 = 0.40$, $P > 0.05$), and white ($\chi^2 = 0.41$, $P > 0.05$) students in the Natural Sciences and Engineering (Table 1). For all population groups, therefore, differences in scientific literacy only occur at very coarse levels of differentiation such as between the sciences and the non-sciences.

Gender. Males had higher levels of scientific literacy than females in all population groups (Table 2), which accords with the widely documented association between gender and general achievement in science (see, for example, references cited in Kelly[31–33]). A significantly greater proportion of males (60 %) than females (40 %) took science subject combinations that included Physical Science (Fisher's exact test — one-tailed, $P < 0.00001$). It is well-known that females are generally underrepresented in physics (see, for example, Kelly[32]). As Physical Science was found to play a particular role in the scientific literacy of matriculants (see below), the difference in science subject combination of male and female students probably accounts for the difference in scientific literacy levels between genders.

Statistically significant gender-based differences in scientific literacy were found only for African and white students and not for coloured and Indian students (Table 2). Sixty-four per cent of female coloured and Indian students either took Physical Science in addition to Biology, or Physical Science together with Biology and Geography, in matric compared to only 41 % of female African and white students (Fisher's exact test – one-tailed, $P < 0.00001$).

Although we noted gender-based differences in performance

Table 2. The percentage of scientifically literate male and female matriculants by population group. In each case the sample size is given in brackets. The value of the χ^2-statistic and the corresponding significance level for the gender comparison within each population group and for the total sample are also presented.

	African	Coloured	Indian	White	Total
Male	14 (250)	30 (493)	58 (38)	49 (1399)	41 (2180)
Female	8 (345)	25 (595)	52 (29)	42 (1070)	32 (2039)
χ^2-statistic	5.23	3.09	0.065	10.0	38.24
Significance level	$P < 0.05$	ns*	ns*	$P < 0.005$	$P < 0.0001$

*Not significant ($\alpha = 0.05$).

Table 3. The percentage of scientifically literate matriculants by population group and number of science subjects taken in matric. In each case the sample size is given in brackets.

Number of science subjects	African	Coloured	Indian	White	Total
0	2 (85)	8 (159)	— (1)	17 (137)	10 (382)
1	6 (107)	17 (195)	38 (16)	39 (959)	33 (1277)
2	13 (316)	35 (455)	57 (44)	50 (1127)	41 (1942)
3	12 (84)	33 (274)	— (6)	71 (237)	45 (601)

among white students, the percentage of scientifically literate white female students was nevertheless higher than that of African and coloured students in general (Tables 1, 2).

Number of science subjects. An important question is whether the number of science subjects students take in matric affects their scientific literacy. It would be reasonable to expect those studying more science subjects in matric to be more knowledgeable about a greater number of scientific concepts.

The number of science subjects taken in matric did indeed influence levels of scientific literacy (Table 3). Overall, students who had studied at least one of the five most common subjects in the natural sciences in matric displayed a significantly higher level of scientific literacy (Fisher's exact test – one-tailed, $P < 0.00001$) than those who had taken no science subject (Table 3). There was, however, no significant difference in the scientific literacy of students who had taken two or three science subjects in matric ($\chi^2 = 3.60, P > 0.05$).

Among African students there was no significant difference in the level of scientific literacy of those who took one or no science subject in matric ($\chi^2 = 0.57, P > 0.05$), whereas there were significant differences for coloured ($\chi^2 = 5.30, P < 0.05$) and white ($\chi^2 = 25.60, P < 0.001$) students. For Indian students there was no significant difference between those taking two or only one science subject in matric ($\chi^2 = 1.07, P > 0.05$, with Yates' correction). For white students there was a significant difference between those who took three and those who took only two science subjects ($\chi^2 = 31.7, P < 0.001$). There were no significant differences for African ($\chi^2 = 0.11, P > 0.05$) and coloured ($\chi^2 = 0.33, P > 0.05$) students who took two or three science subjects.

In summary, therefore, students who took at least one science subject in matric were likely to be more scientifically literate than those who studied no science. It was, however, not necessarily true that taking three science subjects in matric led to higher levels of scientific literacy than a background of only two. Different science subjects, and combinations of them, may influence the level of scientific literacy of students, and this issue is examined next.

Science subject combination. Students with Geography and Physical Science were the most literate overall (Table 4). At the other end of the scale, a background of only Biology, or only Geography, or Biology together with Geography, led to the lowest level of scientific literacy (Table 4). Overall, there was no significant difference in the level of scientific literacy of students who took these three subject options ($\chi^2 = 1.83$, d.f. $= 2, P > 0.05$). In addition, there was no significant difference in the level of scientific literacy of students who took Physical Science alone, or Biology and Physical Science, or Biology together with Geography and Physical Science ($\chi^2 = 1.33$, d.f. $= 2, P > 0.05$). At least two out of five students with Physical Science in matric, either by itself or in combination with other science subjects, were classed as scientifically literate (Table 4).

In general, based on matriculants' performance on the TBSL, three patterns of scientific literacy with respect to science subject combination can be identified. First, Physical Science plays an important role in the scientific literacy of high-school leavers, as the level of scientific literacy of students including Physical Science in their science subject combination was consistently higher than for students who did not. (It is important to note here that the TBSL is not numerically biased with respect to test-items in the physical and chemical sciences.[27]) Second, there is consistent evidence that the effect(s) on scientific literacy of taking only Biology in contrast to Biology with Geography, are similar. Therefore, in terms of scientific literacy, there seems to be no apparent gain to taking Geography in addition to Biology. Third, African students consistently had the lowest level of scientific literacy of all population groups in every science subject combination, and displayed levels that were only one third to one fifth as high as students in the population group with the highest scientific literacy level (Table 4).

General discussion

This survey has confirmed that variables such as the number and combination of science subjects taken in senior high-school, are likely to have an influence on scientific literacy. In particular, the differential impact on scientific literacy — as measured by the TBSL — of taking Physical Science, Biology, and Geography, has been highlighted. The issues raised with regard to the influence of different science subjects on different dimensions of scientific literacy in general, and the influence of Physical Science on scientific literacy in particular, require further

Table 4. The percentage of scientifically literate matriculants for the most frequent science subject combinations by population group. In each case the sample size is given in brackets.

Science subject combination	African	Coloured	Indian	White	Total
Biology	5 (80)	14 (162)	— (6)	27 (326)	20 (574)
Biology and Geography	7 (91)	20 (119)	— (4)	34 (170)	23 (384)
Biology and Physical Science	18 (188)	40 (336)	61 (36)	53 (670)	44 (1230)
Physical Science	17 (12)	42 (24)	50 (10)	47 (549)	46 (595)
Biology, Geography and Physical Science	14 (58)	33 (273)	— (6)	72 (223)	47 (560)
Geography and Physical Science	— (4)	0 (0)	— (4)	60 (247)	59 (255)
Geography	— (8)	— (8)	0 (0)	31 (61)	25 (77)
Other subjects or subject combinations	6 (66)	— (2)	0 (0)	36 (77)	23 (145)

examination and provide interesting directions for further research.

The most striking finding was that levels of scientific literacy of students from different population groups largely reflect the hierarchy of inequality due to previous apartheid policies: coloured and African students fared progressively worse than white students. Similar research needs to be repeated with a larger number of African students in order to ensure that results have a sufficiently large degree of generality. These recommendations apply particularly to the sample of Indian students, who displayed high levels of scientific literacy but constituted only a very small group of unknown representativeness.

Levels of scientific literacy attained by matriculants in this survey are essentially not comparable with the findings of surveys from other countries for basically three main reasons. First, although the development of the TBSL was based on the conceptual approach underpinning most national and cross-national surveys, the TBSL takes a different, essentially complementary, approach to measuring scientific literacy.[27,34] The relatively small number of items with unspecified content validity used in other surveys has been replaced in the TBSL by a much larger set of test-items with demonstrably high content validity.[27,34] Second, performance standards were used for all three dimensions of scientific literacy measured by the TBSL. In contrast to previous studies, there thus exist threshold levels for the scores on the three subtests of the TBSL that need to be met or exceeded in order for individuals to be classified as scientifically literate.[27] Third, previous studies conducted surveys of scientific literacy among the general adult population, whereas the current study focused only on young adults at the secondary/ tertiary education interface. Moreover, as the current method of measuring scientific literacy is novel, no other surveys have as yet used this approach and, hence, no comparisons are possible, either in South Africa or elsewhere.

In order to assess the ability of South African high-schools to produce scientifically literate school leavers, it was appropriate to conduct the survey with matriculants. But until levels of scientific literacy among all matriculants, and not only those entering tertiary education, are estimated, an appraisal of the ability of the South African education system as a whole to produce scientifically literate matriculants remains speculative. This is an obvious direction for future research.

Levels of scientific literacy reported here provide baseline data with respect to the selected matriculants entering tertiary education in immediate post-apartheid South Africa. As such, the information can be regarded as a useful resource for policy makers and may well inform planning of appropriate education policies, as well as possible intervention strategies with respect to achieving scientifically literate school leavers.

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1. Durant J.R. (1993). What is scientific literacy? In *Science and Culture in Europe*, eds. J.R. Durant and J. Gregory, pp. 129. Science Museum, London.
2. Jenkins E.W. (1994). Scientific literacy. In *The International Encyclopedia of Education*, vol. 9 (2nd edn), eds. T. Husen and T.N. Postlethwaite, pp. 5345. Pergamon Press, Oxford.
3. Laugksch R.C. (in press). Scientific literacy: a conceptual overview. *Sci. Ed.*
4. Miller J.D. (1983). Scientific literacy: a conceptual and empirical review. *Daedalus* **112**, 29–48.
5. Laugksch R.C. (1996). *Development of a test for scientific literacy and its application in assessing the scientific literacy of matriculants entering universities and technikons in the Western Cape, South Africa.* Ph.D. thesis, University of Cape Town.
6. Bloch E. (1986). Basic research and economic health — the coming challenge. *Science* **232**, 595–599.
7. Hurd P. De H. (1989). Science education and the nation's economy. In *This Year in School Science. Scientific Literacy*, eds A.B. Champagne, B.E. Lovitts and B.J. Callinger, pp. 15–40. American Association for the Advancement of Science, Washington, D.C.
8. Walberg H.J. (1983). Scientific literacy and economic productivity in international perspective. *Daedalus* **112**, 1–28.
9. Pouris A. (1989). *The Hidden Crisis — S & T Manpower Development in South Africa.* Foundation for Research Development, Pretoria.
10. Miller J.D. (1987). Scientific literacy in the United States. In *Communicating Science to the Public*, eds D. Evered and M. O'Connor, pp. 19–40. Wiley, London.
11. Miller J.D. (1989). Scientific literacy. Paper presented at the annual meeting of the American Association for the Advancement of Science, San Francisco.
12. Durant J.R., Evans G.A. and Thomas G.P. (1989). The public understanding of science. *Nature* **340**, 11–14.
13. Lucas A.M. (1987). Public knowledge of biology. *J. Biol. Educ.* **21**, 41–45.
14. Lucas A.M. (1987). Public knowledge of radiation. *Biologist* **34**, 125–129.
15. Lucas A.M. (1988). Public knowledge of elementary physics. *Phys. Educ.* **23**, 10–16.
16. Foundation for Research Development (1996). *SA Science and Technology Indicators — 1996.* Pretoria.
17. Bureau of Industry Economics (1995). *Science Understanding and Awareness: How Australia Ranks in International Surveys (Occasional Paper 30).* Australian Government Publishing Service, Canberra.
18. National Science Board (1989). *Science & Engineering Indicators — 1989 (NSB 89-1).* U.S. Government Printing Office, Washington, D.C.
19. National Science Board (1991). *Science & Engineering Indicators — 1991 (NSB 91-1).* U.S. Government Printing Office, Washington, D.C.
20. National Science Board (1993). *Science & Engineering Indicators — 1993 (NSB 93-1).* U.S. Government Printing Office, Washington, D.C.
21. National Science Board (1996). *Science & Engineering Indicators — 1996 (NSB 96-21).* U.S. Government Printing Office, Washington, D.C.
22. Glover P.H. (1992). *Unwilling to school: science teaching and the possibility of scientific literacy through science education for black school students in the Ciskei, South Africa.* Ph.D. thesis, University of Oregon.
23. Pouris A. (1993). Understanding and appreciation of science among South African teenagers. *S. Afr. J. Sci.* **89**, 68–69.
24. Central Statistical Service (1995). *October Household Survey 1994.* (Statistical release P0317). Pretoria.
25. File J. (1994). Organising for equity: some thoughts on a tertiary education system in the Western Cape. In *Changing by Degrees*, ed. B. Kaplan, pp. 100–125. UCT Press, Rondebosch.
26. Krige D., Dove S., Makalima B. and Scott D. (1994). *The Education Atlas of South Africa.* Indicator Press, Durban.
27. Laugksch R.C. and Spargo P.E. (1996). Construction of a paper-and-pencil Test of Basic Scientific Literacy based on selected literacy goals recommended by the American Association for the Advancement of Science. *Public Understand. Sci.* **5**, 331–359.
28. American Association for the Advancement of Science (1989). *Project 2061 — Science for All Americans.* Washington, D.C.
29. Everitt B.S. (1992). *The Analysis of Contingency Tables* (2nd edn). Chapman and Hall, London .
30. Bokhorst F.D., Foster D.H. and Lea S.J. (1992). Factors affecting academic performance in first-year psychology at the University of Cape Town. *S. Afr. J. high. Ed.* **6**, 59–65.
31. Kelly A. (ed.). (1981). *The Missing Half: Girls and Science Education.* Manchester University Press, Manchester.
32. Kelly A. (ed.). (1987). *Science for Girls?* Open University Press, Milton Keynes.
33. Kelly A. (ed.). (1987). Editor's introduction: gender and science [Special issue]. *Int. J. Sci. Ed.* **9**.
34. Laugksch R.C. and Spargo P.E. (1996). Development of a pool of scientific literacy test-items based on selected AAAS literacy goals. *Sci. Ed.* **80**, 121–143.

Appendix

Examples of the test-items included in the *Test of Basic Scientific Literacy* (TBSL) are given below. (For further details on the development of the test-items and the construction of the TBSL, see Laugksch and Spargo.[27,34]) Items are listed under the subtest corresponding to each of the three dimensions of scientific literacy. A 'T' or 'F' distinguishes true and false items, respectively. Respondents were asked to read each statement (i.e., item) carefully and to decide whether the statement is true or false, or whether they did not know the answer. (The effect of guessing on the classification of scientifically individuals was examined. On the implausible assumption that all 4223 respondents selected answers randomly from the true and false options only, a misclassification rate of less than 1.5 % was determined.[5] This means that the presence of an unknown number of such random guessers among the respondents to the TBSL does not make any consequential difference to the inferences to be drawn from the large dataset obtained in the scientific literacy survey.)

Nature of Science Subtest

Science assumes that the basic rules about how the universe operates are the same throughout the universe. (T)

In carrying out an investigation, no scientists must be made to feel that s/he should reach a particular result. (T)

Science Content Knowledge Subtest

The earth is as old as the universe. (F)

The earth's atmosphere has been unaltered by the presence of life. (F)

All things of the physical world are made up of different combinations of about 100 chemical elements. (T)

Nothing in the universe — from atoms to living things to stars — is at rest, but is always moving relative to something else. (T)

Many of the basic functions of organisms, such as the extraction of energy from nutrients, are carried out at the level of the cell. (F)

The genetic information encoded in DNA molecules plays no role in the assembly of protein molecules. (F)

The elements that make up the molecules of living things are continuously recycled. (T)

Any new-born animal will show certain patterns of behaviour without having been taught such behaviour. (T)

The good health of individuals is independent of people's collective effort to take steps to keep their air, soil, and water safe. (F)

Impact of Science and Technology on Society Subtest

Engineers can design solutions to all our problems. (F)

No matter what precautions are taken or how much money is spent, any technological system can fail. (T)

Book Reviews

Landmark synthesis of archaeological heritage

Human Beginnings in South Africa: Uncovering the Secrets of the Stone Age. By H.J. Deacon & J. Deacon. 1999. David Philip, Cape Town. ISBN 0-86486-417-5. R120

South Africa approaches the new millennium a greatly changed country. Over the past century the theory and practice of South African archaeology have also undergone considerable transformations, both influenced by and influencing the development of the subject elsewhere in the world. It is thus highly appropriate that, almost two decades since the country's Stone Age past was last comprehensively reviewed, two of the subject's leading practitioners should have written *Human Beginnings in South Africa*. In no more than 200 pages they succeed in offering a beautifully crafted, well-written and amply illustrated introduction to the subject for the general reader and the student, but one which will also be of value to their professional colleagues. Most of the book follows a chronological sequence, divided into 10 chapters. In addition, 32 box features provide more detailed information on topics ranging from how stone artefact assemblages are analysed, to similarities between humans and chimpanzees, to the dating of the Apollo 11 rock paintings, the oldest rock art known anywhere in Africa. All but Chapter 1 are also preceded by brief introductions, many of which draw upon the personal histories as archaeologists of the authors who, between them, notch up some 80 years or so of professional engagement with the discipline.

The Deacons have divided the production of the book between them, Janette concentrating on Later Stone Age hunter-gatherers and herders, and Hilary on the earlier prehistory of the region and the palaeoenvironmental context for human behaviour. A first chapter establishes the challenge of investigating the precolonial past of South Africa and shows how successive generations of archaeologists have sought to investigate it. Chapter 2 then considers the chronological, climatic and environmental frameworks which archaeologists use to investigate and reconstruct the past. Thereafter, successive chapters contextualize humans within the order Primates and examine the fossil and archaeological evidence for understanding the australopithecines, early members of the genus *Homo* and the emergence of modern humans. With Chapter 7 Janette Deacon picks up the story and the final four chapters consider patterns of innovation and change within the Later Stone Age, the Later Stone Age (LSA) as Khoisan prehistory, rock art and the lifeways of Khoekhoe herders over the last 2000 years.

Throughout, the Deacons draw upon their own massive contribution to South African archaeology at such key sites as Melkhoutboom, Boomplaas, Wilton, Nelson Bay Cave and Klasies River Mouth. This is perhaps most obvious in discussing patterning in the LSA artefact sequence, which explicitly concentrates on sites from the southern and eastern Cape. The downside of this emphasis on the Eastern and Western Cape provinces, which are indeed among the archaeologically best known parts of South Africa, is that other areas do not receive as much attention as they might. Recent work in the eastern Free State, the LSA of the Northern Cape and even that of KwaZulu-Natal, for example, is not as prominent as might be expected. On the other hand, the authors do move beyond the narrow confines of present-day South Africa to draw upon work in neighbouring countries such as Namibia and Zimbabwe. This is particularly so when considering, with great skill and sensitivity, the extent to which anthropological observations of recent and contemporary Khoisan communities can be used to investigate not just subsistence strategies, but also the social organization of LSA people; issues of gender relations, exchange and belief systems are all prominent (Chapters 8 and 9).

Without going into detailed discussion of the contents of individual chapters, this book also helps establish the significance of southern African archaeology for world prehistory as a whole. Both through consideration of specific case-studies and more generally, it emphasizes the importance of the South African record for any discussion of early hominid evolution (Chapter 3), the emergence of modern humans (Chapter 4), the understanding of rock art (Chapter 9) and the application of stable isotope techniques to analyses of palaeodiet (Chapters 3 and 8); these are all fields in which South African archaeology is a world leader. Inevitably there will be points of contention between the conclusions drawn here and those favoured by other archaeologists — some of the interpretations of the Klasies River Mouth sequence for inferring the behavioural competence of the anatomically modern humans found there, for example. Equally, though I appreciate the necessity of combating the inheritance of the anti-scientific, anti-evolutionary bias of Christian National Education (*sic*), perhaps the extended discussion of primates in Chapter 3 might have been reduced to make way for a much fuller treatment of what happened to South African hunter-gatherers over the last two millennia of contact with iron-using farming communities and during the past few centuries of European colonization and expropriation.

But these are minor points when weighed against the book as a whole. South African archaeology has long awaited a popular, readable synthesis that provides an update on Ray Inskeep's (1978) *The Peopling of Southern Africa*. This is it, and what a success it is, all the more so for its strong commitment to the preservation of South Africa's archaeological heritage, to public education and to establishing archaeology's relevance to a world threatened by large-scale environmental change and the destruction of cultural diversity. Though the Deacons begin by expressing the hope that this book will encourage others to improve upon their own efforts, there can be little doubt that *Human Beginnings in South Africa* will stand as a landmark synthesis for many years to come and as a tribute to the dedication and scholarship of its authors.

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The numerate ecologist

Numerical Ecology. By P. Legendre and L. Legendre. 1998. Second English Edition. Elsevier, Amsterdam. Pp. 853. US$150.00 (hbk); US$73.50 (pbk).

Let us, as biologists, never underestimate the power of the numerical tool and, at the same time, never become slaves to numbers. *Numerical Ecology* pitches its message straight at the fulcrum of this adage. It empowers the reader by comprehensively covering the variety and mechanics of the tools available. It cautions against slavery by stating that numerical approaches can never replace the requirement for ecological reflection. The authors also constantly emphasize the relevance and application of numerical tools to ecology, in its broadest biological sense.

Just like many a tool, owning one and understanding its mechanics often suggests opportunities for creation that may not have been considered previously. In this way, reading *Numerical Ecology* will quite possibly

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