

Preparedness for tertiary chemistry: Issues of placement and performance of academic development programmes

M. Potgieter

Department of Chemistry
University of Pretoria
South Africa
e-mail: marietjie.potgieter@up.ac.za

B. Davidowitz

Department of Chemistry
University of Cape Town
South Africa
e-mail: bette.davidowitz@uct.ac.za

S. S. Mathabatha

Department of Chemistry & Chemistry Technology
Walter Sisulu University
South Africa
e-mail: smathabatha@wsu.ac.za

Abstract

The introduction of an outcomes-based curriculum in South Africa together with a new syllabus for physical sciences for grades 10–12, prompted the development of an instrument to monitor conceptual understanding in chemistry at the secondary-tertiary interface. This instrument was used to evaluate placement within different programmes at tertiary institutions as well as improvement in the conceptual understanding of chemistry during the first year of instruction. Comparison of preparedness revealed distinct profiles for proficiencies of mainstream and academic development cohorts, respectively, at the Universities of Cape Town, UCT, and Pretoria, UP, but not at the University of Limpopo, UL, which raises doubts about the placement of students at that institution. Unnecessary duplication of offerings for under-prepared students was found at UP. The academic development programmes at UCT and UP were effective in raising the level of conceptual understanding of students while students in the UL programme showed very little improvement.

BACKGROUND

The South African Department of Education has introduced major changes in the curriculum for the Further Education and Training phase of secondary schooling

(grades 10–12) since 1994. It was decided to adopt an outcomes-based approach and to introduce new or revised syllabi for all subjects, including Physical Sciences. The National Curriculum Statement for Grades 10–12 refers in its introduction to the need for learners in the 21st century ‘to be exposed to different and higher level skills and knowledge than those required by the existing South African curricula’ (Department of Education 2005, 2). In view of these changes, Potgieter, Davidowitz and Venter (2008) developed an instrument to assess and monitor baseline conceptual understanding of students on first entry to tertiary chemistry in order to identify any significant shifts that may arise from the implementation of the new curriculum. Since many South African universities offer academic development programmes (for example, extended curricula or foundation programmes) for under-prepared students, this instrument also has the potential to be used to evaluate current placement procedures as well as to monitor the performance of academic development programmes in terms of addressing under-preparedness.

The purpose of this article is to contribute to the debate regarding placement of weaker students in programmes where they have optimal prospects of success while balancing the placement decision against cost implications for all stakeholders. In this regard we have set out to answer the following research questions:

- How well prepared are first-year students from South African schools for chemistry upon entry to tertiary education?
- How successful are current placement policies in terms of distinguishing between students with different levels of preparedness for tertiary chemistry?
- How does the preparedness of students who exit from academic development programmes compare with that of mainstream students who enter tertiary chemistry directly?

LITERATURE REVIEW

Issues of selection and placement at tertiary institutions are especially challenging in the South African context where past and present inequalities have to be addressed while maintaining fairness and transparency. Students enter tertiary education with a wide range of proficiencies and different levels of preparedness. A number of studies have been reported in this journal on admissions testing for science programmes (Grussendorf, Liebenberg and Housten 2004; Koch, Foxcroft and Watson 2001; Koch and Foxcroft 2003), prediction of performance based on selection tests (Eiselen, Strauss and Jonck 2007) and retention (Lourens and Smit 2003). While tertiary institutions are still using the results of school-leaving (Matric) examinations as the main admission criterion, several authors have questioned the validity and fairness of such results especially for disadvantaged students from ex-DET (Department of Education and Training) black-only education systems (Herman 1995; Yeld and Haeck 1997).

Zaaiman, Van der Flier and Thijs (2000) have argued that selection is a contract to teach at the students' level. Selection of a student into a specific programme carries a strong message of expectation of success. Issues of access and selection are therefore closely related to issues of retention and success. They have questioned placement criteria at the University of the North (now University of Limpopo, UL) because the prospect of success of direct entry students in science programmes was shown to be significantly weaker than that for students who entered after first completing the foundation year Programme, UNIFY, offered at that institution.

The high failure rates observed at South African tertiary institutions, especially for disadvantaged students can be attributed partly to the lack of adequate support after admission (Scott, Yeld and Hendry 2007). Koch et al. (2001) have found that most students lack the core competencies required for success at tertiary level. Mainstream programmes do not make adequate provision for the development of these competencies. However, academic development programmes generally provide not only intensive training for conceptual understanding; they also focus on the development of academic skills and provide counselling, support and career guidance (Grayson 1996; Mabila, Malatje, Addo-Bediako, Kazeni and Mathabatha 2006; Davidowitz and Schreiber 2008). Thus the placement of a borderline student in either mainstream or a development programme provides or denies access to support mechanisms which may be required for success.

Many universities in South Africa use alternative admissions tests, for example, the Alternative Admissions Research Project tests (AARP 2007a and b) together with results of the Grade 12 examinations for access or placement or to assess students' learning needs (Eiselen et al. 2007; Grussendorff et al. 2004; Koch et al. 2001; Van der Flier, Thijs and Zaaiman 2003). The Higher Education South Africa (HESA) National Benchmark Tests Project (Griesel 2006) has developed tests in the areas of verbal reasoning, quantitative literacy and mathematical proficiency in an attempt to provide schools and higher education institutions with information about the competencies of students on entry to Higher Education. These tests will not reproduce the essential information derived from the school-leaving examinations. The HESA initiative is expected to address broad issues of admission regulation and engage in the development of benchmark mechanisms within the higher education sector. It will, however, not produce subject specific results to inform chemistry teaching and student placement within specific programmes at South African Higher Education institutions.

Zaaiman and co-workers (2000) have demonstrated that if selection testing is closely linked to the teaching programme for which selection is done the prospects of success for students admitted to the programme are optimised. Several admissions test instruments specifically for chemistry have been described in the literature, but none of them are tailor made for the South African context (McFate, and Olmsted III 1999; Mulford and Robinson 2002; Toledo Chemistry Placement Exam; Wagner, Sasser and DiBiase 2002). We have designed an aptitude test combined with some elements of achievement testing for the joint purposes of diagnosis and prediction, that is, to serve

as an indicator of preparedness for first-year chemistry and to optimise its predictive ability for success in first-year chemistry. The design criteria and performance of this instrument is reported elsewhere (Potgieter et al. 2008). In this article we describe the use of this instrument to evaluate both placement decisions and the effectiveness of academic development programmes to address under-preparedness in chemistry in South Africa. Data was collected at three institutions which are representative of the South African tertiary landscape, that is, the Universities of Cape Town, Pretoria and Limpopo (UCT, UP and UL), respectively, and the results are expected to be relevant to other tertiary institutions in South Africa as well.

CONTEXT

The structure of academic development programmes offered by different tertiary institutions in South Africa varies. The universities of Cape Town and Limpopo offer a single academic development programme for students who do not qualify for direct entry into the mainstream programmes, the UCT extended programme and University of the North foundation year (UNIFY) programme, respectively. The University of Pretoria offers two development programmes for different target groups, the extended programme and the UP foundation year (UPFY) programme, respectively. These programmes are briefly described in Table 1. The minimum requirement for admission to the mainstream programmes at both UCT and UP is a D symbol (50–59%) for higher grade mathematics, whereas the equivalent of an F symbol (33–39%) for higher or standard grade mathematics is sufficient to enrol for mainstream science at UL. Students who did not meet the entrance requirements for mainstream programmes at UP and UCT were selected for academic development programmes at these institutions based on the results of school leaving examinations together with selection tests which assess basic language and mathematical aptitude (AARP tests, 2007a and 2007b). Selection for the UNIFY programme is based on tests specifically developed to assess English language proficiency and identify students' potential in mathematics and science. Candidates must have passed the matriculation examination (have at least a school leaving certificate) with mathematics and one of the science subjects (physical science, biology or agriculture) taken to Grade 12 level, but not necessarily passed (Mabila et al. 2006). Similarly, students were selected for the UPFY programme based on the results of the Matric examination and three selection tests. However, students were required to have achieved a pass in mathematics as well as either physical science or biology (minimum F symbol on either standard or higher grade). Due to the preference of a major funding donor the UPFY programme was accessible only to students of colour, whereas the UP extended programme was accessible to all.

METHODOLOGY

Research questions one and two as stated above probe the level of preparedness of different cohorts of students for tertiary chemistry and therefore require a quantitative survey of proficiencies of chemistry students before any instruction at tertiary level has taken place. In order to address research question three regarding the effectiveness of development programmes to address under-preparedness for chemistry, post-test data was collected for foundation year and extended programme students upon exit from these programmes.

The test instrument used for data collection was designed to cover fundamental concepts generally accepted as pre-knowledge for first-year chemistry and to assess conceptual understanding rather than recall or procedural knowledge (Potgieter et al. 2008). The instrument includes items to assess representational competence, that is, the ability to interpret symbolic, semantic and schematic representations, as well as specific items with proven predictive power for success in chemistry at first-year level. Items assessing basic mathematical ability are included since mathematical ability is well documented to be one of the strongest predictors of success in first-year general chemistry (McFate and Olmsted III 1999; Wagner et al. 2002). The test instrument consists of 65 test items that are divided into two similar subtests (Test A and Test B) in order to restrict the time required to administer the test. Each subtest consists of 37 items including 9 common anchor items, to allow for the equating of the subtests and subsequent merging of data. The items are grouped into 11 subsets covering basic chemistry topics, special content topics and two categories of scientific process skills (Tables 2 and 3). The same instrument was used for post-test data collection, except that items on electrochemistry were removed since none of the syllabi for academic development programmes included electrochemistry.

The raw score data collected was transformed into interval data using the Rasch statistical model (Bond and Fox 2001; Boone and Rogan 2005; Potgieter et al. 2008). Applying the Rasch model enhances the quality of a project at various levels. The rigour of analysis is increased and the assumption of linearity is met – an assumption often ignored in the analysis of educational data. In calculating raw scores, correct answers contribute equally to overall student performance irrespective of item difficulty. The Rasch model converts non-linear raw score test data into linear measures of performance (person measures) and linear measures of item difficulty (item measures). Correct answers contribute to overall performance according to the level of difficulty of the test items in question. Person measures are a more accurate indication of performance and level of preparedness than traditional raw scores results.

The internal consistency of the subtests of the instrument was demonstrated (Cronbach alpha coefficients between 0.80 and 0.83 for the benchmark cohorts, i.e. mainstream students at UP and UCT), and Rasch analysis of the data showed an item reliability of 0.99 and person reliability of 0.81 (Potgieter et al. 2008). Rasch analysis also confirmed that there was an excellent match between the range of difficulties

of test items (item measures) and the performance range (person measures) for the benchmark cohorts, and that all levels of difficulty are adequately covered by test items. Potgieter et al. (2008) have reported moderate correlation of person measures with academic performance in mainstream first-year chemistry at UCT and UP ($r = 0.56$) which compares favourably with correlations of 0.30–0.60 between course grades and pre-assessment scores reported in the literature (Wagner et al. 2002). The predictive validity of the instrument for performance at a historically black university such as UL has not been investigated.

SAMPLE

Data was collected at the beginning of the academic year in 2005 and 2006. The sample consisted of three groups of first-year students at UP, and two groups each at UCT and UL, see table 1. Since the study was designed to document the proficiencies of students who received their secondary education according to the South African education system, the sample excluded students who completed high school outside South Africa or sat for international school leaving examinations. In addition, students repeating the course or entering without any background in physical science did not participate in the study.

Table 1: Cohorts participating in the study

Group	Number of respondents	Description
Mainstream cohorts		
UP	513	First-year students who meet entrance requirements to the Science Faculty at the particular university. Students at UCT and UP are likely to have attended high schools that were reasonably well resourced. Students at UL have generally attended high schools that were poorly resourced.
UCT	258	
UL	156	
Extended programmes		
UP	103	Mostly black students from disadvantaged backgrounds. The mainstream first-year syllabus is covered over a period of 18 months (UCT) or two years (UP) and is supported by extensive supervised problem solving sessions.
UCT	103	
Foundation programmes		
UP (UPFY)	189	One-year programmes for black students with good aptitude from disadvantaged communities. These programmes seek to prepare students for tertiary education by remediation of shortcomings in school background and strengthening of conceptual understanding of fundamental concepts.
UL (UNIFY)	183	

FINDINGS

The results for the investigation of preparedness of students for tertiary chemistry (research questions 1 and 2) will be presented both as raw scores and person measures.

Comparison of raw score results within cohorts

The performance of different cohorts of students as reflected by raw score data is presented in Tables 2 and 3. Correct, partially correct and incorrect answers were assigned scores of 1.0, 0.5 and 0.0, respectively. A *performance index* was calculated per subtopic for each cohort of students as the average of the percentages of correct answers per test item (raw scores) in the subset. The standard errors in the table reflect the range of difficulties for the items in a particular subset. For example, the mean of 65.8 per cent for the subset Atoms and Ions for the UP cohort was calculated from an average of correct answers between 22.4 per cent and 85.6 per cent for the individual questions in that subset.

Table 2: Performance index as measure of preparedness in basic chemistry concepts (%): mainstream students at UP, UCT and UL

Topic (Subset)	N (items)	UP (N = 513)	Std error	UCT (N = 258)	Std error	UL (N = 156)	Std error
Basic Concepts							
Atoms and Ions	8	65.8	8.7	68.1	7.4	32.9	7.7
Mole concept	6	52.4	10.1	58.8	11.2	32.3	6.4
Phases of matter	8	56.8	6.2	65.2	5.9	23.1	4.2
Solutions	6	51.7	9.1	56.6	10.0	28.2	5.2
Reactions	8	35.8	7.6	41.4	6.1	24.3	5.3
Special Topics							
Acids and Bases	6	65.6	6.2	58.7	6.8	39.0	6.9
Chemical equilibrium	6	53.5	8.0	51.4	8.9	29.3	8.6
Electrochemistry	5	39.6	6.4	44.0	8.7	22.4	4.0
Organic chemistry	6	58.0	8.1	53.3	8.7	33.0	6.6
Process skills							
Skills (Maths)	10	51.8	8.2	60.0	7.3	32.5	5.6
Skills (Comprehension)	6	46.1	8.5	53.3	8.8	17.5	7.7

It is evident from the raw score results presented in Tables 2 and 3 that the best performance was observed for UP and UCT mainstream cohorts. The performance of UL mainstream was weaker than all of the academic development cohorts at both UP and UCT. At UP, mainstream students outperformed students in the extended programme, who, in turn, marginally outperformed UPFY students. Similarly, UCT mainstream students performed significantly better than the UCT extended programme cohort. The performance of the UNIFY cohort was close to the random guess level for most of the subtopics. These general trends in performance reflect the admission policies at the different institutions and the fact that prestigious institutions can select applicants from bigger pools of academically strong applicants.

Table 3: Performance index as measure of preparedness in basic chemistry concepts (%): extended programme and foundation year cohorts at UP, UCT and UL

Topic (Subset)	N (items)	Extended programmes				Foundation year programmes			
		UP (N=103)	Std error	UCT (N=103)	Std error	UPFY (N=189)	Std error	UNIFY (N=183)	Std error
<i>Basic Concepts</i>									
Atoms and Ions	8	50.4	8.8	43.8	8.9	42.8	8.1	24.5	5.9
Mole concept	6	42.3	10.3	38.7	6.6	38.0	9.6	30.2	4.7
Phases of matter	8	49.9	6.2	35.8	5.9	45.6	4.8	20.1	3.4
Solutions	6	47.1	8.9	39.4	6.4	40.8	8.0	25.7	3.8
Reactions	8	27.5	6.4	27.9	6.8	27.3	7.4	19.8	4.2
<i>Special Topics</i>									
Acids and Bases	6	50.6	7.5	49.4	7.6	46.6	5.8	26.7	3.0
Chemical equilibrium	6	38.6	9.4	34.5	11.8	36.3	11.5	23.9	9.7
Electrochemistry	5	28.3	9.2	21.3	4.9	28.0	4.6	17.7	2.6
Organic chemistry	6	46.1	10.1	39.6	7.1	38.5	9.1	25.0	4.9
<i>Process skills</i>									
Skills (Maths)	10	45.0	7.1	37.7	6.3	43.7	7.2	22.5	4.1
Skills (Comprehension)	6	32.8	8.9	24.4	6.9	31.4	11.2	10.9	4.5

Table 4 shows the composition of the different mainstream cohorts of students at UCT, UP and UL according to their Grade 12 results for mathematics. A thorough analysis of response frequencies of individual test items highlighted a number of

aspects with direct implications for teaching at first-year level. These results have been reported elsewhere (Potgieter, Davidowitz and Blom 2005).

Table 4: Performance of mainstream cohorts in Grade 12 final mathematics examination^a

Cohort (year)	Composition of cohorts according to Grade 12 final examination results ^b											
	% HG symbols						% SG symbols					
	A	B	C	D	E	F	A	B	C	D	E	F
UCT (2005)	39	21	22	10	3	0	4	1	0	0	0	0
UP (2005)	25	20	29	23	2	0	<1	<1	0	0	0	0
UL (2006)	<1	3	5	11	13	0	16	12	16	12	9	2

^aExcluding students who sat for international school leaving examinations

^bHG = higher grade, SG = standard grade

Comparison of person measure results within cohorts

Figures 1 and 2 illustrate the ranges of person measures for mainstream cohorts and academic development programmes, respectively. Given the close match between the range of difficulties of items and the performance of the benchmark cohorts (Potgieter et al. 2008) a person measure of 0.0 logits was taken as an indication of adequate level of preparedness for mainstream chemistry at high ranking South African universities. Figure 1 confirms that the majority of mainstream students at UCT and UP are better prepared for first-year chemistry than students in any of the other cohorts. By contrast, only a small number of UL mainstream students achieved person measures of 0.0 logits or above. This result corresponds to their Grade 12 mathematics performance according to which fewer than 20 per cent of UL mainstream students would have qualified for selection to UP and UCT mainstream science programmes.

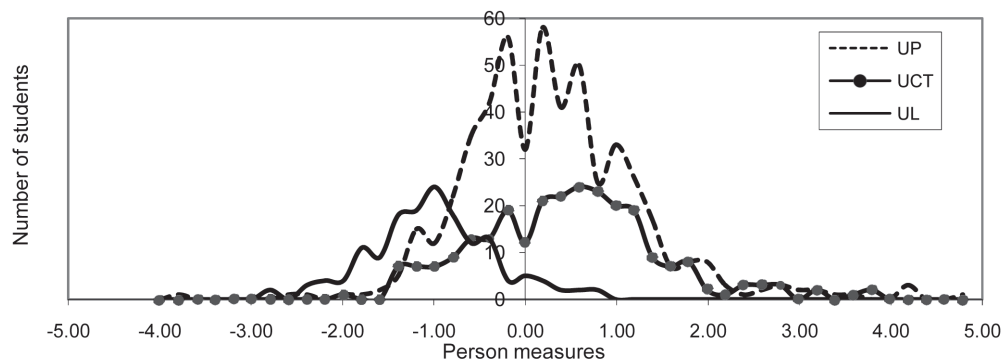


Figure 1: Person measures for the mainstream cohorts at the Universities of Pretoria (UP), Cape Town (UCT) and Limpopo (UL)

Most of the students in the foundation or extended programmes are poorly prepared for tertiary chemistry. A careful comparison of the person measure distributions for the UPFY and UP extended programmes in Figure 2 shows that there is virtually no difference in the range of abilities of these groups of students. This finding raises questions regarding the rationale for offering two development programmes for

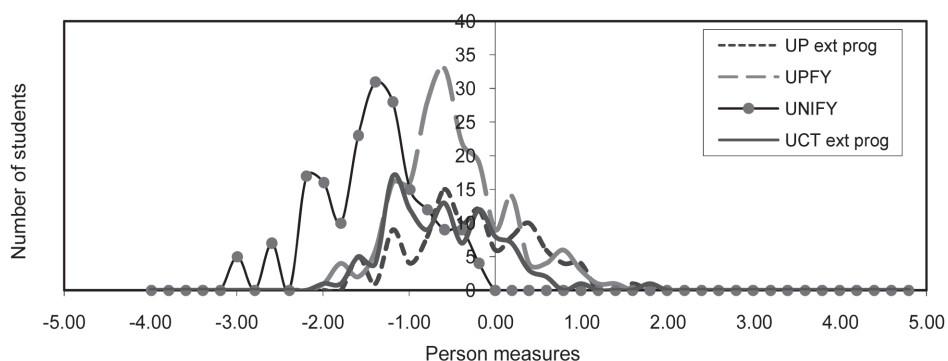


Figure 2: Person measures for academic development cohorts at the Universities of Pretoria, Cape Town and Limpopo

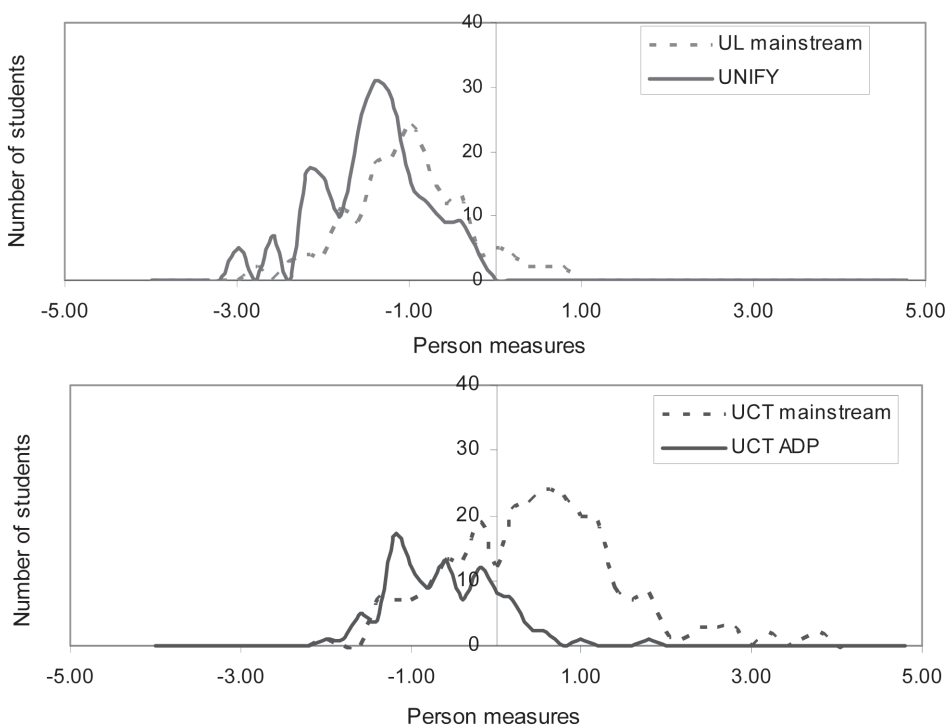


Figure 3: Comparison of person measures for the academic development and mainstream programme cohorts at the Universities of Limpopo and Cape Town, respectively

under-prepared students at the same institution, which seems to duplicate rather than complement each other in terms of the entry level of students.

A comparison of the ranges of person measures for mainstream and academic development programmes for the Universities of Limpopo (UL) and Cape Town (UCT) is shown in Figure 3. Mainstream chemistry students at UL are only marginally better prepared than those in the foundation programme (UNIFY), whereas there is a clear difference in the preparedness of the two cohorts at UCT. Not only will an extensive intervention be required for both cohorts at UL to reach exit levels comparable to that of the mainstream cohorts at UCT and UP, but placement policies may also have to be refined to optimise the offerings at that institution. Zaaiman and co-workers (2000) questioned the use of an F-symbol as cut-off value for entry to mainstream BSc at UL considering the high failure rate observed at first-year level. They proposed raising the minimum performance requirement to a D-symbol for higher grade mathematics following tracer studies between 1994 and 1996.

Pre-test vs. post-test raw score results for development programmes

Research question 3 investigates the success of academic development programmes offered at the three institutions to prepare students for mainstream chemistry. Foundation year students at UP and UL are prepared to enter mainstream chemistry after successful completion of the one-year programme, but the extended programme at UCT spans 18 months after which students proceed to second year chemistry modules. In order to judge whether the deficit in preparedness upon entry was successfully addressed, the results of pre- and post-tests for foundation year cohorts at UP and UL were compared with the performance of direct entry mainstream students of the following year. It was not logistically possible to make a similar comparison of exit level *versus* entry performance for UCT. Instead, post-test data for the development cohort was collected after one year and the results were compared with pre-test results of the mainstream cohort of the same year in order to obtain an indication of the gains achieved during the first year of teaching.

The performance of different cohorts of students as reflected by raw score data is presented in Table 5. Items on electrochemistry were excluded from the post-test and a small number of free response items were removed during post-test data collection in 2005 in order to facilitate data processing. This affected the number of items included in the comparison of results for the special topics Acids and Bases, Chemical Equilibrium, Organic Chemistry and Skills (Comprehension). Thus the percentages quoted for the pre-tests for some cohorts may be different from those in Tables 2 and 3.

The data presented in Table 5 were analysed for general trends rather than for the interpretation of specific results. It is clear from the post-test results for the UPFY cohort that the performance of foundation year students in almost all topics improved significantly to be at least on par with direct entry mainstream students at UP. The

poor performance of the UPFY cohort on aspects of Chemical Equilibrium can be explained by the fact that for practical reasons the post-test was written before this topic was explicitly taught. Significant improvements in performance on all of the subtopics were also documented for the UCT development programme. By contrast, the post-test results for the UNIFY cohort indicates that significant gains (more than the standard errors of pre- and post-test results) were only achieved for the subtopics Atoms and Ions, Phases of Matter and Skills (Maths). Post-test performance on many subtopics was still at the random guess level.

One of the explicit objectives of academic development programmes is that in-depth conceptual understanding of subject content should be cultivated for students who did not have access to quality instruction during their secondary education. The test instrument used for this study was specifically designed to probe conceptual understanding rather than factual recall. It is clear from these findings that the desired outcomes were not achieved for the UNIFY programme.

Table 5: Comparison of pre- and post-test results (%) for different cohorts at UP, UL and UCT

		Atoms and Ions	Mole concept	Phases of Matter	Solutions	Reactions	Acids & Bases	Equilibrium	Organic chemistry	Skills (Maths)	Skills (Comprehension)
UP Cohorts	Year										
UPFY Pretest	2004	39.9	33.9	34.2	36.0	24.7	47.6	22.0	39.5	35.5	27.8
UPFY Posttest	2004	63.8	53.2	66.7	45.5	29.2	73.1	18.4	50.2	54.3	50.9
Mainstream Pretest	2005	65.8	52.4	56.8	51.7	30.7	69.8	45.1	56.8	51.8	46.1
UL Cohorts	Year										
UNIFY Pretest	2005	24.5	30.2	20.1	25.7	20.1	26.7	23.9	25.0	22.5	15.7
UNIFY Posttest	2005	31.7	35.3	29.4	29.8	20.2	25.5	25.4	28.7	32.2	18.4
Mainstream Pretest	2006	32.9	32.3	23.1	28.2	23.8	39.0	29.3	33.0	32.5	22.3
UCT Cohorts	Year										
ADP Pretest	2005	43.8	38.7	35.8	39.4	25.7	49.4	34.5	39.6	37.7	32.7

ADP Posttest	2005	63.3	52.3	55.5	50.7	38.3	73.4	51.6	52.5	52.7	61.7
Mainstream Pretest	2005	68.1	58.8	65.2	56.6	38.4	58.7	51.4	53.3	60.0	66.3

DISCUSSION

The University of Limpopo is one of South Africa's historically black universities and attracts students from primarily educationally disadvantaged backgrounds (Zaaiman et al. 2000). By comparison, the Universities of Cape Town and Pretoria are two high ranking South African institutions (Academic Ranking of World Universities 2006) which attract students of significantly higher academic standing from South Africa and other countries to their mainstream programmes. The results produced by this study regarding preparedness of students upon entry to tertiary chemistry reflect this reality. Foundation and extended programmes are designed to address deficiencies in the level of preparedness of students entering tertiary education in the sciences. As such, the UPFY programme at UP was effective in raising the preparedness of students to the level required for mainstream chemistry as offered at that institution. Similarly, significant gains were observed for the UCT academic development cohort. By contrast, the UNIFY programme did not achieve the gains in conceptual understanding of chemistry that could reasonably be expected from such a focussed and well resourced programme.

The small difference in the range of proficiencies for the mainstream and UNIFY cohorts at UL raises doubts about the placement criteria that were used. Since admission criteria for mainstream chemistry at all three institutions is based mainly on Matric results, the findings in this study contribute to the concern of several authors about the validity of Matric results as predictor of further performance for low-scoring, disadvantaged students from the previous DET black-only education systems (Van der Flier et al. 2003 and references cited therein). At UP there seems to be a duplication of offerings for under-prepared students as evidenced by the similar range of proficiencies of extended programme and UPFY cohorts upon entry.

As a result of recent changes in the funding formulae of the Department of Education, foundation year programmes offered at tertiary institutions will no longer be subsidised (Department of Education 2006). This has forced tertiary institutions to rethink their offerings to under-prepared students. The foundation year programmes at UP and UL have recently been terminated; instead extended degree programmes will be offered in future. It is not clear, however, whether these structural changes at UL have been accompanied by a redesign of placement procedures as well. Placement and performance in chemistry will be monitored for all programmes at UCT, UP and UL as part of this ongoing research project.

POTENTIAL IMPLICATIONS FOR HIGHER EDUCATION IN SOUTH AFRICA

This study has the following implications for placement at UL: The large majority of all students enrolling for first-year chemistry at UL require the intensive academic support that is typically provided through academic development programmes. The current placement procedures do not discriminate in a convincing manner between students of different levels of preparedness for tertiary chemistry. The study also validates the recent decision by UP to offer only one academic development programme (B.Sc. four-year programme) instead of two programmes (UP foundation year programme and UP extended programme) by showing that the latter two former programmes were an unnecessary duplication. Lecturers of mainstream chemistry at UCT and UP are alerted to the fact that upon entry to tertiary education first-year students are poorly prepared for electrochemistry and many of the concepts related to chemical reactions. Finally, the study demonstrates the significant gains in knowledge and conceptual understanding of chemistry achieved through the academic development programmes offered at UCT and UP.

ACKNOWLEDGEMENTS

The authors wish to acknowledge Ms Elsie Venter for the Rasch analysis of data and Mr Ubbo Smith for very helpful suggestions and information regarding the UNIFY and UPFY programmes.

REFERENCES

- Academic Ranking of World Universities, Institute of Higher Education, Shanghai Jiao Tong University. August 2006. Available at: <http://ed.sjtu.edu.cn/ranking2006.htm>. Accessed on 29 January 2008.
- Alternative Admissions Research Project (AARP). 2007a. The Placement Test in English for Educational Purposes (PTEEP): The Tea Test. AARP, Academic Development Programme, University of Cape Town.
- Alternative Admissions Research Project (AARP). 2007b. The Mathematics Comprehension Test (MCOM). AARP, Academic Development Programme, University of Cape Town.
- Bond, T. G. and C. M. Fox. 2001. *Applying the Rasch model*. New Jersey: Lawrence Erlbaum Associates.
- Boone, W. and J. Rogan. 2005. Rigour in quantitative analysis: The promise of Rasch analysis techniques. *African Journal of Research in Science, Mathematics and Technology Education* 9:25–38.
- Department of Education. 2005. National Curriculum Statement Grades 10–12 (General) Learning Programme Guidelines. Available at: http://curriculum.pgwc.gov.za/php/circular_docs/55_maths.pdf. Accessed on 29 January 2008.
- Department of Education. 2006. *Funding for foundational provision in formally approved programmes: 2007/08 to 2009/10*. Pretoria: Department of Education.

- Davidowitz, B. and B. Schreiber. 2008. Facilitating adjustment to higher education: towards enhancing academic functioning in an academic development programme. *Journal of Higher Education* 22 (1): 191–206.
- Eiselen, R., J. Strauss and B. Jonck. 2007. A basic mathematical skills test as predictor of performance at tertiary level. *Journal of Higher Education* 21 (1): 38–49.
- Grayson, D. 1996. A holistic approach to preparing disadvantaged students to succeed in tertiary science studies. Part 1. Design of the Science Foundation Programme. *International Journal of Science* 18:993–1013.
- Griesel, H. (Ed.). 2006. *Access and Entry Level Benchmarks. The National Benchmark Tests Project*. Pretoria: Higher Education South Africa – HESA.
- Grussendorff, S., M. Liebenberg and J. Houston. 2004. Selection for the science foundation programme (University of Natal): the development of a selection instrument. *South African Journal of Higher Education* 18:265–272.
- Herman, H. D. 1995. School-leaving examinations, selection and equity in higher education in South Africa. *Comparative Education* 31:261–274.
- Koch, S. E. and C. D. Foxcroft. 2003. A developmental focus to admissions testing: admissions and placement standards development. *Journal of Higher Education* 17:192–208.
- Koch, E., C. Foxcroft and A. Watson. 2001. A developmental focus to student access at the University of Port Elizabeth: process and preliminary insights in placement assessment. *Journal of Higher Education* 15:126–131.
- Lourens, A. and I. P. J. Smit. 2003. Retention: predicting first-year success. *South African Journal of Higher Education* 17 (3): 169–176.
- Mabila, T. E., S. E. Malatje, A. Addo-Bediako, M. M. M. Kazeni and S. S. Mathabatha. 2006. The role of foundation programmes in science education: The UNIFY programme at the University of Limpopo, South Africa. *International Journal of Educational Development* 26:295–304.
- McFate, C. and J. Olmsted III. 1999. Assessing student preparation through placement tests. *Journal of Chemical Education* 76:562–565.
- Mulford, D. R. and W. R. Robinson. 2002. An inventory for alternate conceptions among first-semester General Chemistry students. *Journal of Chemical Education* 79:739–744.
- Potgieter, M., B. Davidowitz and B. Blom. 2005. Chemical concepts inventory of first year students at two tertiary institutions in South Africa. In *Proceedings of the conference of the South African Association of Research in Mathematics, Science and Technology*, ed. J. Adler. Windhoek: SAARMSTE.
- Potgieter, M., B. Davidowitz and E. J. Venter. 2008. Assessment of preparedness of first-year chemistry students: development and application of an instrument for diagnostic and placement purposes. *African Journal of Research in Mathematics, Science and Technology Education*, in press.
- Scott, I., N. Yeld and J. Hendry. 2007. A case for improving teaching and learning in South African higher education. *Higher Education Monitor No. 6*. Pretoria: Council on Higher Education.
- Toledo Chemistry Placement Exam, Examinations Institute of the American Chemical Society Division of Chemical Education. Available at: <http://www4.uwm.edu/chemexams/materials/exams.cfm>. Accessed on 29 January 2008.
- Van der Flier, H., G. D. Thijs and H. Zaaiman. 2003. Selecting students for a South African mathematics and science foundation programme: the effectiveness and fairness of

- school leaving examinations and aptitude tests. *International Journal of Educational Development* 23:399–409.
- Wagner, E. P., H. Sasser and W. J. DiBiase. 2002. Predicting students at risk in General Chemistry using pre-semester assessment and demographic information. *Journal of Chemical Education* 79:749–755.
- Yeld, N. and W. Haeck. 1997. Educational histories and academic potential: can tests deliver? *Assessment and Evaluation in Higher Education* 22:5–16.
- Zaaiman, H., H. Van der Flier and G. D. Thijs. 2000. Selection as a contract to teach at the students' level. Experiences from a South African mathematics and science foundation year. *Higher Education* 40:1–21.