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Selection as contract to teach at the student's level. Experiences from a South African mathematics and science foundation year

HERMIEN ZAAIMAN[1], HENK VAN DER FLIER[2,*] & GERARD D. THIJS[3]
[1]*UNIFY Programme, University of the North, 27 11th Street, Parkhurst 2193, Johannesburg, South Africa;* [2]*Department of Industrial and Organizational Psychology, Vrije Universiteit, v.d. Boechorststraat 1, 1081 BT Amsterdam, The Netherlands;* [3]*Faculty of Science, Dept. Social Aspects of Science and Technology,Vrije Universiteit, de Boelelaan1081, 1081 HV Amsterdam, The Netherlands (*Corresponding author: Phone: 020-4448712; Fax: 020-4448702; E-mail: H.van.der.Flier@psy.vu.nl)*

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Abstract. The selection of students is a critical issue currently facing South African higher education institutions. The identification and selection of disadvantaged students with the potential to succeed in mathematics- and science-based study is a particularly pressing problem. The new South African higher education law requires that selection is done in a fair and transparent manner. Selection has to be followed by adequate support for selected students to succeed in their study programmes. Issues of access are closely coupled to issues of retention and success. The research results discussed in this paper illustrate how these issues can be successfully addressed and how selection fairness and effectiveness may be optimised under the constraints of selection efficiency. An optimal solution can be found by developing test specifications and selection cut-off values based on the teaching programme for which the selection is done. The resulting close fit between selection testing and teaching after selection leads to a reasonable expectation of success for selected students in the study programme. Under such conditions, selection can be seen as a contract to teach at the student's level.

Keywords: critical incidents technique, development and evaluation of selection mechanisms, higher education, identification of students with academic potential for mathematics and science, incoming student specification, predictive validity, research into fair, effective and efficient selection instruments, selection, selection cut-off scores, test specifications

Introduction

The selection of students is a critical issue currently facing South African higher education institutions. Recent changes in the South African educational system have intensified the need for proven fair selection. The new South African Higher Education Act of 1997 places responsibility and accountability for the selection of students for higher education at institutional level. Admission policies must provide for appropriate measures for redress of past inequalities and may not unfairly discriminate in any way.

Higher education is seen as a key allocator of life chances and must be actively involved in achieving equity among South African citizens through the distribution of opportunity and achievement (DOE 1997a).

In South Africa, the educational backgrounds of applicants for higher education vary widely in terms of quality of school education received. The newly released School Register of Needs Survey, covering the physical facilities, services, equipment and teaching resources of every school in South Africa reveals strong differences in the educational situation in South African schools (DOE 1997b). The most underresourced schools are the ones that belonged to the previously black-only educational systems. These schools still typically have few qualified science and mathematics teachers and inadequate or non-existent physical facilities (Arnott, Kubeka, Rice and Hall 1997). As a result, small percentages of black students matriculate in mathematics and science subjects. Approximately one black student for every 60 white students attains matriculation exemption with physical science and mathematics as subjects (DACST 1996). Most South African black matriculants do not qualify for entrance into science-based courses on the grounds of their Matric results. The differences in educational opportunities at school level complicate the development of fair and effective selection mechanisms. The identification of students with the potential to succeed in further study despite previous educational disadvantage is a problem for which most South African higher education institutions still have to find adequate solutions.

The high failure rates and low numbers of students in the science-based faculties at the University of the North in South Africa led to the UNIFY programme. UNIFY stands for University of the North Foundation Year. The University of the North is one of South Africa's historically disadvantaged institutions. It is situated in the mainly rural Northern Province and was established during the apartheid era for black students. In the post-apartheid era, the majority of students who apply to study at this university still come from educationally disadvantaged backgrounds.

UNIFY is a mathematics and science foundation year which was established in 1993. The aim of UNIFY is to give disadvantaged South African students a chance to enter and succeed in the University of the North's science-based faculties. It is a one-year programme that caters for 150 students. UNIFY has adopted a student-centred approach to teaching where staff act as facilitators. Emphasis is placed on problem-solving skills rather than content knowledge. Five subjects are covered, namely: biology, chemistry, English and study skills, mathematics and physics.

Applicants for UNIFY are regarded as having been disadvantaged if they had inadequate access to quality educational services resulting in a lack of opportunity to fully develop their academic potential. Zaaiman (1998) showed that students who attended the South African previously black-only schools could be regarded as having been educationally disadvantaged. UNIFY therefore targets students from these schools who demonstrate potential to succeed in mathematics- and science-based study despite their disadvantaged backgrounds. Such students have to be identified from an applicant pool consisting mainly of applicants with weak matric results who would not have been able to enter BSc first-year study directly.

South African problems of selection and access are not unique and are also reported in other countries as discussed by Zaaiman (1998). There is an international need for relevant research results on which the development and evaluation of selection mechanisms can be based. This paper illustrates a number of selection issues using research results from a four-year UNIFY Selection Research Project. Starting in 1994 this project was run at the University of the North in cooperation with Vrije Universiteit Amsterdam in the Netherlands. Its main aim was to establish a validated selection mechanism for UNIFY that would be fair, effective and efficient. A second aim of the project was to establish general selection guidelines that could be used for selection in other programmes.

Fair, effective and efficient selection

Selection must serve the aims of the programme for which the selection is done. Selection is usually required to be fair, effective and efficient.

The main aim of selection in higher education is to identify students who will succeed in a specific academic programme. In reality, selected students will either pass or fail (the true and false positives) and some rejected students would have been able to pass (the false negatives). The social and financial costs of selecting the wrong students are high. The aim of selection should therefore be to minimise the false positives and false negatives in the selected and rejected groups. An effective selection mechanism will select a high percentage of successful students and reject as few potentially successful students as possible. Factors that should increase the effectiveness of a selection test include high predictive validity, selecting top-down instead of at random above a cut-off score, and a large applicant pool that is varied in ability around the required ability level (Hunter and Hunter 1984; Schmitt 1989; Bartram 1995).

The evaluation of selection fairness involves psychometric as well as contextual aspects of the selection mechanism (Jensen 1980; Linn 1984). The discussion here will focus on fairness in terms of the acceptability of the selection mechanism to those affected by it. Selection involves making decisions about the futures of applicants. This means that selection decisions impact directly on individuals, communities and on society in general. Not being selected generates feelings of rejection and disappointment that can lead to a sense of inferiority and/or injustice among applicants, regardless of background (Lerner 1978). One must therefore expect selection decisions to be challenged legally and politically.

The acceptability of a selection mechanism depends on the context in which the selection occurs. A selection mechanism can be psychometrically valid but unacceptable to the community. On the other hand, it is easier to defend a psychometrically valid selection mechanism as being fair on the grounds of empirical evidence.

It is often pointed out that satisfying the requirements of fairness and effectiveness in an efficient and acceptable way is difficult (Drenth, Van der Flier and Omari 1983; Altink and Thijs 1984; Herman 1995). This is especially true in a society where past injustices have left members of certain population groups more disadvantaged than others. The selection of the students with the highest probability to succeed may lead to underrepresentation of the disadvantaged groups. The selection of more disadvantaged students through the implementation of affirmative action may lead to a smaller probability of success in the selected group, as well as the rejection of qualified, privileged applicants. The selection practitioner must find the optimal fit between fairness and effectiveness for the required situation.

Selection processes operate under logistical constraints, such as time limitations, financial constraints and large numbers of applicants. An efficient selection mechanism will operate under these constraints in an optimal manner. In this discussion, the focus will be on optimising selection fairness through close selection test-teaching programme fit and selection effectiveness as evidenced by high predictive validity for further performance. Although selection efficiency is not discussed in detail here, it is acknowledged that the requirement of efficiency will tend to limit the effectiveness and fairness that can be achieved during selection.

Selection as contract

Selecting a student carries as much responsibility as rejecting one. This is especially true when selecting previously disadvantaged students. In South Africa, the high failure and corresponding low progression rates of underprepared black students at universities reflect a failure to support disadvantaged students adequately after admission (DOE 1996).

This concern not only holds for the South African situation but is also mentioned in international literature. An example is the assertion by Bird, Yee, Sheibani and Myler (1992) that British higher educational institutions' commitment to accessibility for black people is often not adequately supported after admission, leading to low progression rates. To admit students who do not have adequate probability to succeed in higher education is generally regarded as unethical (Bean 1986; Harman 1994; Browne-Miller 1996). Morrow (1994) distinguishes between formal access and epistemological access. To Morrow formal access means the ability to gain entrance to a programme while epistemological access concerns learning how to become a participant in academic practice.

Selection of a student is seen here as an implicit contract to teach at that student's level. This means that every selected student must have a reasonable expectation of success after admission to a study programme. This can be achieved by either adjusting the teaching programme to the level of the entering students or by adjusting the entrance requirements to the level of the teaching programme. This implies that for teaching to take place at the selected student's level, selection mechanisms must be closely coupled to the programme selected for. It also implies that the programme selected for must suit the needs of the available or targeted students. In the UNIFY Selection Research Project, this approach to selection was expected to optimise both selection fairness and effectiveness.

The view of selection implying a contract to teach at the student's level corresponds with the South African Department of Education's principle of equity, which requires fair opportunities both to enter and succeed in higher education as stated in the higher education White Paper (DOE 1997a). According to the Department of Education, equity of access must be complemented by a concern for equity of outcomes. Issues of access and selection are therefore closely linked to issues of retention and success.

Selection requirements

It follows from the above discussion that both the level of the teaching programme and the applicant level affect the fairness and effectiveness of selection mechanisms. On the one hand, the selection mechanism should be closely coupled to the teaching programme. On the other hand, both the selection mechanism and the teaching programme should fit the level of preparation of the kind of applicant the programme is intended for.

The first step in the process of maximising the fairness of a selection mechanism is to know what has to be assessed, as well as what should not be assessed (Feltham and Smith 1993). In the functional approach to testing, the design of a test is determined by its use. The functional approach to selection requires a clear definition of the purpose of the assessment and of the selection instruments. Tests are designed using test specifications based on a task specification, which is usually based on the curriculum in the educational context or on a job specification in the employment context. Test specifications provide a regulated framework for the choice of test items (Rust and Golombok 1989).

Developing a selection mechanism based on the requirements a programme sets to the selected student can be expected to lead to defensible and fair selection (Payne 1995). In employment selection, job analysis methods are often suggested as an aid to the development or choice of relevant selection instruments (Cook 1988; Algera and Greuter 1989; Schuler 1989). Industrial psychologists use job analysis methods to determine which requirements a job sets for an employee. These requirements include the knowledge, skills and abilities required to do the job effectively. The required characteristics must be specified as unambiguously as possible.

A number of job analysis methods have been developed. One of these is the critical incidents technique. The technique's main aim is to identify the critical requirements of the job. It uses interviews to gather examples of specific behaviours that had previously led to successful or unsuccessful job performance. These event descriptions are called the critical incidents. The critical incidents are evaluated and organised into job categories or dimensions. Latham and Wexley (1982) and Saal and Knight (1995) discuss this technique (developed by Flanagan in 1954) in more detail. The critical incident principles seemed promising for the analysis of the requirements that higher educational programmes set to incoming students and its use was therefore investigated during the UNIFY Selection Research Project.

Research questions

This paper describes the way in which the concept of selection as a contract to teach at the student's level was investigated during the UNIFY Selection Research Project. Issues of selection fairness and effectiveness are addressed. Relevant UNIFY selection research results are used to answer the following research questions:

1) Do the selection tests reflect the minimum entrance requirements for UNIFY students?
2) Are the selection tests effective for the prediction of student performance in UNIFY?
3) Does the selection decision making process based on the tests lead to optimal selection decisions?

Methodology

Research was done using the performance of the UNIFY applicants in the UNIFY selection tests and of the selected students in the UNIFY programme.

The time period covered was from 1994 to 1996. Question one was investigated by analysing the existing selection mechanism, identifying a lack of test specifications and creating such test specifications. The programme requirements were determined using interviews based on the critical incidents technique mentioned above. The requirements were then translated into an incoming student specification. The incoming student specification was used to identify the selection instruments needed in the selection mechanism and to develop the selection test specifications.

Question two regarding the effectiveness of the UNIFY selection mechanism was evaluated by determining the predictive validity of the UNIFY selection tests. Predictive validity was calculated by correlating selection test performance with the performance in UNIFY as measured by the UNIFY final average score taken over all the subjects. Multiple regression analyses were used to check which of the selection tests identified during the test specification development process significantly contributed to the predictive validity of the tests.

The third question was investigated by checking whether the selection cut-off score could be defended. This was done using expectancy graphs that show the proportion of students passing against the selection predictor score. Lastly, an illustration of where selection helped to satisfy the contract to teach at the student's level and where the selection requirement did not satisfy this contract is given. These examples are based on tracer studies of the performance of ex-UNIFY students in first-year BSc courses compared to the performance of non-UNIFY students in first-year BSc study.

Student and test specifications

The initial UNIFY selection tests consisted of a mathematics selection test and a science selection test. These tests were based on tests developed in similar projects in Southern Africa where the Vrije Universiteit had been involved. They were aptitude-styled tests, aimed at testing subject-related problem-solving skills and insight, with as little as possible content knowledge required. But even though most of the items had been in use for many years, test specifications did not exist. During test modification, item behaviour was evaluated using item-analysis data. The staff members responsible for the related subject then modified or replaced items when necessary.

The absence of agreed-on test specifications complicated the evaluation of item content, as well as the proposal of new items. During discussions of the 1994 UNIFY selection item-analysis data, it often happened that a poorly functioning item was declared a 'good item, which should work' by the staff member responsible for such an item. Such a statement was difficult to dispute without an accepted test specification. It was also difficult to suggest alternatives to a problematic item without a specification on which to base such suggestions. The need for valid and acceptable test specifications was thus identified. The question of what was being tested, and why, required a specific answer. A systematic and rational way to determine the requirements for success or failure in UNIFY was therefore needed.

In 1995, it was decided to analyse the requirements set by UNIFY to the incoming student by focusing on the actual performance of selected students in the programme. Critical incident interviews were held with all 15 UNIFY staff members. During the interviews, examples of student behaviour that led to successful and unsuccessful performance in UNIFY were gathered. The descriptions were used to compose a list of 221 behavioural statements describing successful and unsuccessful performance in UNIFY. Examples of such behavioural statements are:

> "The student could not formulate an understandable sentence in English."
> "The student took only text notes in class with no diagrams or graphs included."
> "The student drew a proper vertical axis."

The critical incidents were then used to form performance categories by sorting the behavioural statements into groups that contained similar types of behaviour. The behavioural statements within the categories were ranked according to their importance to performance in UNIFY.

The behavioural statements and performance categories were used to determine the minimum requirements UNIFY sets to the incoming student. This process led to the creation of an incoming student specification. This specification gave a detailed description of the incoming characteristics of a potentially successful UNIFY student under the headings: specification number, required ability and level at which this ability is required (high, intermediate and basic). It was intended to cover the critical incident interview material as well as possible after eliminating disputed statements.

The incoming student specification was then used to suggest possible selection instruments by mapping the student requirements on the existing and other possible predictors. Selection instruments that could be applied under the existing logistical constraints such as the large applicant numbers, were chosen. For example, it was decided that selection interviews would be impractical and difficult to apply in a fair manner in the UNIFY case.

Test specifications were then developed based on the incoming student specification. These test specifications were used in the evaluation and development of the UNIFY selection tests and procedures by checking test items against the test specifications. The UNIFY incoming student specification and an example of a test specification are given in Zaaiman (1998). This

Table 1. The main UNIFY critical performance categories mapped onto the existing and suggested selection tests

UNIFY critical performance categories		Mathematics	Science	English	Arithmetic
A.	Ability to understand and evaluate the presented material.	V	V	V	X
B.	Numeracy skills.	V	V	X	V
C.	Diagrammatic and graphing skills.	V	V	X	X
D.	Practical (laboratory) skills.	X	V	X	X
E.	English language skills.	V	V	V	X
F.	Ability to work fast enough.	V	V	V	V
G.	General qualities that will help the student to adjust to UNIFY and campus life.	X	X	X	X

V or X indicate whether selection test includes or excludes a particular performance category.

process supported the testing of mathematics and science skills as done in the existing mathematics and science selection tests. Two new selection tests were suggested and developed on the grounds of the critical incident process and the incoming student specification. The English selection test assessed English proficiency using mainly an open-ended question format. The arithmetic selection test was intended to assess basic arithmetic skills and was a multiple-choice test. These two tests were included for testing purposes in the 1996 and 1997 UNIFY selection test batteries.

Table 1 shows the main critical performance categories and the mapping of these categories on the existing and suggested selection tests. Each of these categories consisted of subcategories that described them in more detail and each subcategory skill would be tested by one or more of the selection tests. Category G contained aspects such as communication skills, attitude, perseverance, being independent, etc. These attributes were not evaluated during the UNIFY selection process, mainly because of the large numbers of applicants and a lack of validated instruments to assess more personality related attributes for our applicants.

The critical incident interviews worked well as a way to start discussions. However, it was not found to be an easy technique to apply. It was important to ensure that the incidents referred to requirements set for the incoming student and not for the required student level at the end of UNIFY. Avoiding vague and theoretical discussions and staying on a practical level was not always easy.

The UNIFY staff members were fully involved in every step of the process. Meetings were characterised by intense discussion about the meaning and importance of individual behavioural statements and the UNIFY course requirements. Working through the many incidents took time and effort but helped both the researcher and teaching staff understand the requirements UNIFY makes of the incoming student. This process could be expected to also have had an impact on the further development of the UNIFY programme through the clarification of the programme objectives and curriculum requirements during the discussions.

One of the more difficult, but necessary, requirements during the group discussions was that the researcher kept to the role of facilitator and did not become unduly connected to the suggested performance dimensions or specifications. The process outcomes had to stay the property and responsibility of the UNIFY teaching staff members. Such a commitment was expected to help ensure that the selection mechanism relates closely to what is taught and as such helps to satisfy the contract to teach at the student's level.

The major advantage of this process was that the specifications could structure discussions for the further development of the UNIFY selection tests. Disputes about item changes could be referred to the student and test specifications during test development. Another advantage was that the student and test specifications strengthened the defensibility of the UNIFY selection mechanism by ensuring a close connection between the selection tests and the UNIFY teaching programme. The above process addressing the first research question helped ensure that the selection tests reflect the minimum entrance requirements for students as set by the UNIFY programme.

Results

The predictive validity of the UNIFY selection tests for student performance in UNIFY was investigated under research question two. Between 1994 and 1996 the number of applicants to UNIFY varied between 470 and 700. The mean test scores of the applicants on the mathematics and science tests varied between 39% and 43% with standard deviations between 12% and 14%. The distribution of the applicant scores tended to be skewed to the right with more applicants scoring in the lower scoring regions than in the higher scoring regions. Selection was initially done on the average of the mathematics and science selection tests. For the 150 selected students per year, the mean test scores were about 55% on these two tests, with standard deviations of around 10%. UNIFY therefore had a large applicant pool that varied in performance on the selection tests. The internal homogeneity (Cronbach's α) of both the mathematics and science selection tests varied around 0.70, with a minimum of 0.68 and a maximum of 0.75.

Table 2. Predictive validity coefficients of the UNIFY selection tests for UNIFY final performance

	1994	1995	1996
Mathematics Selection Test	0.44**	0.39**	0.41**
Science Selection Test	0.27**	0.38**	0.44**
Average Mathematics and Science Selection Tests	0.49**	0.49**	0.57**
Arithmetic Selection Test	n/a	n/a	0.28**
English Selection Test	0.28**	0.27**	0.30**
New Predictor	0.50**	0.53**	0.59**

** – two-tailed significance less or equal to 0.01.
n/a = not available.

The UNIFY final average score was used as the criterion for the calculation of the predictive validity coefficients. This is the average of the final percentages attained in the five UNIFY subjects. The internal homogeneity of the UNIFY final average score was estimated by calculating the Cronbach's α reliability coefficient for the scores on the five subjects and varied between 0.87 and 0.89 between 1994 and 1996. The mean of the final average scores varied between 56% and 58% with a standard deviation of 8%. The stability evident in the final average data and the consistently high reliability coefficient indicated that the final average score could be regarded as a reliable criterion for UNIFY performance.

Table 2 gives the correlation coefficients between the UNIFY selection tests and final performance in UNIFY. An initial English proficiency test was given to the UNIFY students in the years 1994 and 1995. This test is included in the table as the English selection test for these two years since the 1996 English selection test was based on it and its performance was used in the decision of whether English language skills should be included in the test battery or not.

The selection tests all consistently showed moderate to high significant predictive validity for the UNIFY final results. This high predictive validity can probably be explained by the close connection between the selection tests and the UNIFY programme. The high predictive validity of the average of the mathematics and science selection tests for the UNIFY final performance supported the original decision to use this average for UNIFY selection.

The question of whether the predictive validity of the mathematics and science average could significantly be improved by the introduction of the two new selection tests, was then addressed. Multiple regression analyses were used to investigate whether initial English proficiency added significantly to the prediction of final average performance. Stepwise multiple regression of the final average scores on the mathematics, science and English proficiency tests showed that the English proficiency test did not significantly add to the predictive validity in 1994. But it made a significant difference in 1995 by increasing the multiple R from 0.49 to 0.53 (the F-value for the change was 7.8 with degrees of freedom (df): 1,141. This was significant at $\alpha = 0.01$). By 1996, data for the UNIFY English selection test were available. This test significantly contributed to the predictive validity of the mathematics and science tests for UNIFY final average by raising the multiple R from 0.57 to 0.59 (the F-value for the change was 4.3 with df: 1,142. This was significant at $\alpha = 0.05$). These results, combined with the need for a basic level of initial English proficiency identified during the UNIFY task requirement analysis, led to a decision to include the English selection test in the selection decision-making process in 1997.

Even though the arithmetic selection test scores correlated significantly with the UNIFY final average scores, adding this test to the stepwise multiple regression did not add significantly to the prediction of the final average by the mathematics-, science- and English selection test scores. The internal reliability of the arithmetic selection test was too low at about 0.60 and the test needed further development before it could be useful in the selection process.

It was decided to give the English selection test a weight of 20% in the selection decision-making formula on the grounds of the 1995 and 1996 multiple regression β-values. In 1995, the β-weighting mathematics:science: English proficiency test was 0.3:0.3:0.2. In 1996, the same β-weighting was 0.3:0.4:0.2. It was therefore decided to do selection on the following predictor in 1997:

$$\text{New Predictor} = (2*\text{Mathematics} + 2*\text{Science} + \text{English})/5$$

The predictive validity of this predictor for UNIFY performance is shown in Table 2. Adding the English selection test and using this predictor significantly increased the predictive validity of the original UNIFY selection mechanism. Yearly, the selection tests were also modified and developed according to their fit on the UNIFY applicant pool using item and bias analyses. The consistency of the predictive validity coefficients over the years 1994 to 1996 led to increased confidence in the validity of using these tests for selection to UNIFY. Combining the UNIFY mathematics, science and English selection tests gave high predictive validity for student performance in UNIFY. It can therefore be stated that the UNIFY selection tests are effective for UNIFY selection.

Optimal selection decisions

The third research question addresses the selection decision making process. Up to 1997, selection was done using an arbitrary, non-research-based minimum selection cut-off score of about 43%. The UNIFY selection research data were used to check the validity of this minimum cut-off score. It was decided that the minimum cut-off score should be set as the selection test score above which at least 70% of selected students would be expected to pass UNIFY. Selecting only students who scored above the cut-off score in the selection tests would help to achieve an optimal fit between the level of preparation of the selected students and the teaching programme.

As shown above, the selection research led to a new selection predictor, which included the English selection test scores. The English selection test consisted mainly of open-ended questions and took more time to mark than the computer-marked science and mathematics selection tests. With the large applicant numbers to UNIFY, marking the English selection test for each applicant would have compromised selection efficiency. Using the original average mathematics and science selection scores to set a minimum selection cut-off value solved this problem.

The high predictive validity of this average for performance in UNIFY shown in Table 2 supported this decision. Such a cut-off value was also expected to prevent the selection of students with high English proficiency but with low science and mathematics aptitude. Zaaiman (1998) showed that UNIFY students with high English proficiency probably came from more privileged backgrounds than those with low English proficiency. Therefore, giving English proficiency too great a weight in the selection process could lead to the selection of more privileged students with lower mathematics and science aptitude and the rejection of less educationally privileged students with greater mathematics and science aptitude. Using a minimum cut-off score based only on the mathematics and science selection test scores was seen to be a fair selection option in the context where UNIFY is intended for disadvantaged students.

The applicants who scored above this cut-off value were ranked according to the new selection predictor that included English proficiency. Selection was then done top-down on this rank list. This meant that the English selection tests only had to be marked for applicants who stood a good chance of passing UNIFY based on the required mathematics and science skills as defined by the incoming student specification.

The selection cut-off score was set at the 2.5% average mathematics and science score interval where the proportion of students passing UNIFY could be expected to be 70%. The bottom value of that interval was regarded as the selection cut-off score. Figure 1 shows the expectancy graph plotting

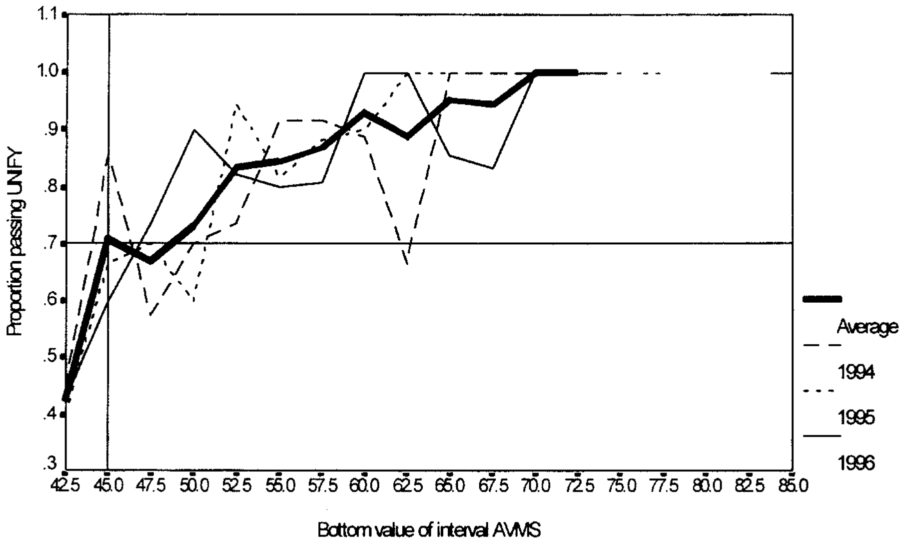

Figure 1. Expectancy graph for passing UNIFY, based on the average of the mathematics and science selection test scores (AVMS).

the proportion of selected students passing UNIFY within a 2.5% average mathematics and science interval. This is shown for the three years, as well as the average proportion passing taken over the three years.

The average line in graph 1 shows that a cut-off score of 45% corresponds to a probability of at least 70% students passing UNIFY. This cut-off score will give an expected 70% UNIFY pass rate if all the selected applicants scored in this interval. In practice, most applicants would be expected to score above the minimum cut-off score and the programme pass rate would be expected to be higher than 70%. This was illustrated by the UNIFY pass rates over the years 1994 to 1996 which varied between 76% and 82%, using an average mathematics and science selection cut-off score of 43%.

Combining an average mathematics and science cut-off score of 45% with the selection of the best applicants on the new predictor above that cut-off score can therefore be expected to lead to optimal selection decisions. Students selected in this way have a success rate of at least 70% in the UNIFY programme they are selected for.

Selection as contract to teach illustrated

We shall now give an illustration of satisfying the contract to teach at the student's level by comparing the performance of the UNIFY students in first year to the performance of non-UNIFY students in first-year BSc study at the University of the North. Two tracer studies were done using the 1995 and 1996 first-year performance of the ex-UNIFY 1994 and 1995 students (Zaaiman 1996, 1997). The studies followed on the tracer study done on the first-year performance of the original 1993 UNIFY group by Smith (1995). Although reliable and comprehensive tracer data were difficult to obtain, the three studies had similar findings. The main results of the tracer studies are summarised here.

Between 80% and 90% of ex-UNIFY students, who had passed UNIFY, registered for BSc first-year study at the University of the North in both 1995 and 1996. The numbers of ex-UNIFY students registering per year were about 100. The non-UNIFY first-year group was divided into two subgroups for the purposes of analysis. The first group was the direct-entry first-time registering group and the second group was the direct-entry repeater group. The repeater group consisted of students who had failed first-year courses and were repeating first-year courses. Many of these students repeated first-year courses more than once. In 1995 and 1996, both the repeater and first-time registering groups numbered about 300 students each. Although the student and course numbers differ between the Smith and Zaaiman studies, the repeater and first-time registering student proportions in the first-year group were similar in all three studies. The 1993 UNIFY student group was smaller than the other UNIFY groups, which meant that fewer UNIFY students registered for first-year courses.

Figure 2 compares the average proportion of students passing first-year courses per subgroup per year. The first-year data show that the 1993, 1994 and 1995 ex-UNIFY students consistently had a greater probability of passing first-year subjects than either the first-time registering or repeater groups. Of course, in comparing ex-UNIFY students with first-time registering direct entry students one has to take into account that the ex-UNIFY students have had an additional year of instruction in UNIFY that was preparing them optimally for the study in the first year. The ex-UNIFY students however also do better than the repeaters, though these have also already spent an additional year on the first year study. This is a significant achievement considering that the groups of ex-UNIFY students contain high proportions of students who would not have been allowed into the faculties on the grounds of their matric results. This can be explained only in that UNIFY apparently offers a better preparation for the study in the first year than just repeating this year.

The tracer data showed that high proportions of non-UNIFY direct-entry students failed first-year courses. Ex-UNIFY students fared better than non-UNIFY students in first year. This situation cast doubt on the validity of the first-year selection criteria.

The entrance criteria for direct entry for first year at the University of the North are based on the matric symbols achieved by students. Matric

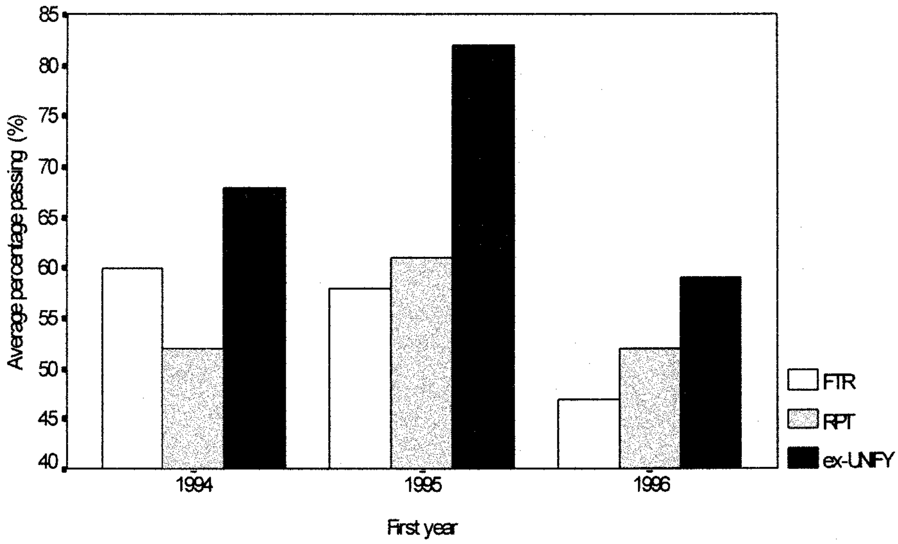

Figure 2. Three-year comparison of average pass rates per subgroup in year one. FTR = First-time Registering; RPT = Repeater.

results are given in terms of the symbols achieved per subject at a specific difficulty level, either higher grade or standard grade. The symbols possible are: A (≥80%), B (70%–79%), C (60%–69%), D (50%–59%), E (40%–49%), F (33%–39%), G (25%–33%) and H (0%–24%). The minimum symbol required to pass a subject at matric is an F. A student needs at least the equivalent of an F on higher grade for matric mathematics to enrol in the Faculty of Mathematics and Natural Sciences. Using an F as entrance cut-off means accepting that some students just managed to pass the subject. Taking into account the high failure rates of students at first year this faculty entrance requirement can be questioned.

To find a matric cut-off value that will allow lecturers to satisfy the contract to teach at the student's level, an exploratory analysis was done. The BSc first-year performance of a sample of 169 1995 first-time registering students was compared against their matric mathematics symbols. The results of this analysis are summarised in Figure 3. These were initial results based on small sample sizes per course but one can see that first-year students who scored less than a D on higher grade in matric mathematics had a small probability of succeeding in first-year BSc courses at the University of the North.

Comparing the direct-entry first-year results with the corresponding first-year performance of ex-UNIFY pass students per matric symbol, one sees that the UNIFY students had been better prepared to succeed in first year than

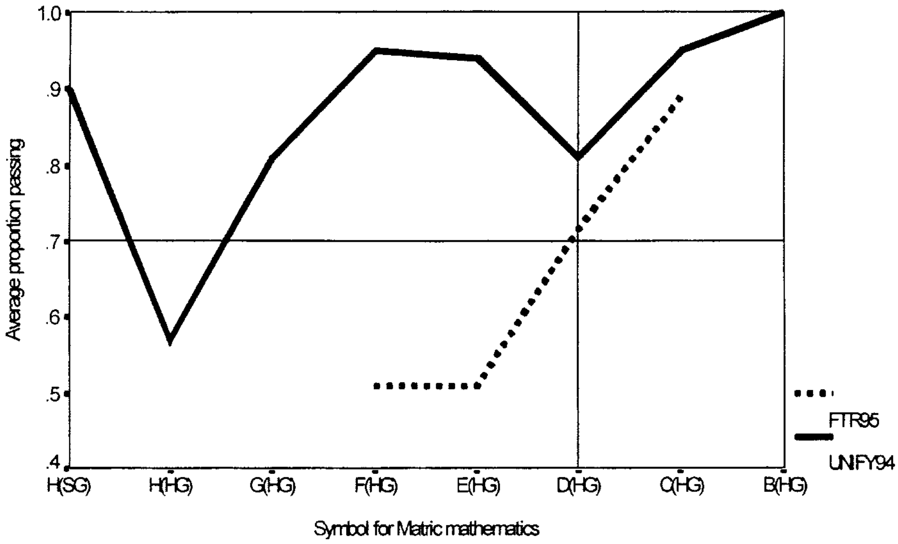

Figure 3. Expectancy graph for succeeding in a University of the North BSc first-year course based on seven subjects for a sample of 1995 first-time registering (FTR) students and the corresponding sample of UNIFY 1994 pass students.

the direct-entry students. Most of the UNIFY students would not have been allowed into the faculty on the grounds of their matric symbols. Yet the tracer study data showed that successful completion of UNIFY is a good predictor of success in the University of the North BSc first-year courses. The UNIFY students generally succeeded in science-based study after having received adequate support. The UNIFY teaching approach can be characterized as an intensive training programme moving students away from rote learning by focusing on conceptual understanding of the most difficult concepts in science and mathematics; spending much time on laboratory work and the training of skills; and intensive counselling, testing and feedback to students (Thijs 1997).

The graph shows that students who passed UNIFY had a greater probability of succeeding in the first year than the non-UNIFY first-time registering students for all matric mathematics symbols. Furthermore, students who first did UNIFY even though they formally qualified to enter first year directly, benefited from UNIFY as more than 80% of UNIFY students with a matric mathematics symbol of greater than an F on higher grade passed UNIFY.

It has been shown above that the research-based changes to the UNIFY selection mechanism increased the fit between the selection tests, the selected students and the teaching programme. This was done through the development of the student and test specifications, the introduction of a predictor with high predictive validity and ensuring an optimal selection decision making process by introducing a research-based minimum selection cut-off score. This enabled the UNIFY staff members to teach the selected students at their level as illustrated by the high pass rates in UNIFY. A selected UNIFY student can therefore expect to be able to pass UNIFY. One can state that the UNIFY selection mechanism allowed the UNIFY staff members to teach at the student's level.

As shown, this is not generally the case for non-UNIFY students allowed into first year. The high first-year failure rates could be reduced by raising the Faculty of Mathematics and Natural Sciences' entrance requirements to at least a D on higher grade for matric mathematics.

Conclusion

The UNIFY selection research work addressed issues that are important in the current South African and international higher education contexts. EU funding for the second phase of UNIFY (1996–1998) was based on its model character towards foundation years at other universities in South Africa. See: Kahn and Volmink (1995) and Thijs (1997). The selection research results are expected to have immediate implications not only for UNIFY but also for other foundation years at the South African universities. An important conclusion from the research is that the identification and selection of disadvantaged students with the potential to succeed in mathematics- and science-based study have to be followed by adequate support for such students to succeed. The UNIFY program, characterised by a student-centred approach to teaching and an emphasis on the development of problem solving skills through experimentation was meant to optimize this support. This implied that the curriculum was tailor made to students that had been defined in terms of the Student and Test Specifications against which the selection tests had been checked. Thus selection and curriculum were fully in line with each other. As discussed in the introduction issues of access are closely coupled to issues of retention and success. The research results discussed in this paper illustrate how these issues can be successfully addressed and how selection fairness and effectiveness may be optimised under the constraints of selection efficiency.

It was shown that disadvantaged students who have been adequately supported to succeed by teaching them at their level are able to achieve well in science and mathematics higher education programmes. It was also shown that students who are allowed into courses without having the necessary educational achievement can not be expected to have an adequate probability to succeed in such courses.

A number of general selection guidelines are evident from the research results and experiences during the UNIFY Selection Research Project: It is suggested that in a situation where high failure rates of students occur, an incoming student specification is developed based on critical incident interviews. The incoming student specification then forms the basis for the development of the selection tests and entrance requirements. Selection tests that do not require much subject content knowledge but assess programme-related skills can be expected to be a fair and effective selection option. The main responsibility for the development of a selection mechanism should preferably rest with the staff members who teach the courses for which the selection is done. Instructional practices should be made as explicit as possible so that the explication procedure can result in clear Student and Test Specifications. Selection researchers should act as facilitators in the evaluation and development of selection tests and instruments. The involvement of teaching staff in setting the entrance requirements to their own courses will empower them to fulfil the selection contract to teach at the student's level. The process described here allowed the UNIFY staff members to create an optimal fit between selection requirements and educational support provided after admission. Using these ideas in other programmes should contribute to fair, effective and efficient selection. This in turn should lead to greater accountability and a realistic opportunity to redress past inequalities through the selection of disadvantaged students and teaching them at their own level.

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