Assessment and evaluation of individual prerequisites for dental education

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Since 2001 the School of Dentistry of Malmö University in Sweden has used an alternative admissions procedure based on results of an investigation supported by the Swedish Council for the Renewal of Undergraduate Education. The investigation concerned possibilities of predicting dental school performance on the basis of an interview, as well as tests of general intelligence, spatial ability, manual dexterity, empathy and social competence. Two groups of incoming students were followed from start to completion of their training. Significant relationships were found between (i) number of course examinations failed and poor results on interviews, as well as low scores on intelligence, spatial ability, and a test of spatial-manual ability, (ii) good results in a pre-clinical course in cavity preparation and high scores on spatial ability, (iii) assessments of high social competence during training and good results on interviews, as well as high scores on empathy and non-verbal intelligence. Dropout from the study programme could not be predicted, possibly due to the varying reasons for it.

Key words: admission model; psychological ability tests; interview; manual dexterity; social skills.

From a societal standpoint it is best that priority in access to resources for higher education be given to those best able to profit from them. Both for this reason and as being faced with serious academic difficulties can be a burden for the individual student, monetarily and timewise, universities have a clear interest in and responsibility for the recruitment of students able to complete their studies with a reasonable degree of success. Various approaches to achieving this have been undertaken.

Tests of general intelligence have been shown to predict educational success in most fields, as well as high occupational performance for work, in particular of a complex, high-level type (1–4). There is also clear support for a positive relationship between grades in secondary school and academic performance at the university, particularly in theoretical as opposed to more applied subjects and in the earlier stages of university education. No clear relationship has been demonstrated, however, between earlier grades and clinical competence in medicine or dentistry (5). Powis (6) for one has suggested that effectiveness and success in medical or dental studies requires not only sound academic ability but also a variety of non-cognitive skills and qualities, along with a positive attitude towards the profession. A personal interview, partly used to assess competence in non-cognitive areas, is often employed nowadays as part of the process of admission to medical or dental school, as well as to other health care education programmes (7).

A selection instrument often used by dental schools is the Dental Admission Test. This includes a subtest concerning the ability to visualise patterns and relationships (8, 9), or what in psychometric terms is called spatial ability (10). A subtest of manual dexterity can also be included in the test (11). Reports of relations between manual dexterity and academic performance in dental students have varied (12–15) and in practice many dental schools have used results of a perceptual ability rather than a manual dexterity test as one of the primary admission criteria (16, 17).

The aim of the present research was to examine further the feasibility of using other selection instruments than school grades and University Standard Aptitude Tests for obtaining suitable and well motivated dental students able to succeed in their studies, as well as for reducing the number of dropouts. It was planned not only that an interview procedure be employed, but also that standardised tests of well-established character be used insofar as possible, partly because of their being available for other test users as well. On the basis of the earlier
findings referred to above and of an analysis we made of the demands placed on candidates in their studies, we decided to make use of tests of general intelligence, spatial ability, manual dexterity, empathy and social competence. In addition, an interview was included. The major investigation carried out involved two successive groups of students admitted to the dental programme a year apart, their being followed throughout their period of dental training. Both cognitive and non-cognitive aspects of their academic performance were assessed. The generally accepted principles for the use and development of psychological tests for selection purposes in the areas of education and employment (18, 19) were adhered to.

Materials and methods

Participants
A total of 191 students – 96 women (mean age = 23 years) and 95 men (mean age = 25 years) – participated in the study. The data were collected in two ways:

1. During the preparatory and planning stages of the project, various tests were tried out in a preliminary way on four successive groups of students admitted during the years 1992—95, a total of 108 students, 62 women and 46 men, being involved. All data that were appropriate was included in the analyses carried out. As not all the students were given all of the tests, the number tested varied between 74 and 108, depending on the test.

2. At the start of the autumn term of both 1996 and 1997, each newly admitted student was tested and interviewed in a day-long simulated admissions procedure. These students had already been admitted in the conventional way on the basis of their grades or their University Standard Aptitude Test results. For practical reasons, the number of students from the two groups (34 women and 49 men) for whom test data are available varies between 79 and 83 persons altogether, depending upon the test involved.

Tests of general intelligence, spatial ability and manual dexterity

Matrices
This is a subtest contained in Deltabatteriet, a test battery published by Psykologiförlaget, and is a shortened Swedish version of Raven’s Matrices, measuring non-verbal intelligence and general problem-solving ability (20).

Tin models and folding
Both published by Psykologiförlaget, measure spatial ability, the latter being a subtest of Deltabatteriet.

Manual speed and accuracy
Manual speed and accuracy (MSA) is taken from the Employee Aptitude Survey, published by Psychological Services, Inc. The manual for this test reports a correlation of $r = 0.26$ between test scores and the grade average of students at the end of their first year of dental school.

Cavity reproduction
This is a test developed within the project. It involves a manual task in which, with use of a much enlarged model of a lower premolar having a mesio-occluso-distal cavity (Fig. 1) the person is to recreate a diminished version of a cavity of this type in a plexiglass cylinder, using a contra-angle handpiece equipped with a finishing bur. A maximum of 1 h was allowed for test completion. The results were evaluated by two judges on a three-step scale, disagreements being resolved by consensus. What was assessed was the ability to transfer the basic proportions of the premolar cavity to the plexiglass cylinder. Samples illustrating assessment levels 3 (best), 2 and 1 are shown in Fig. 2.

Empathy and social competence

Affect Reading Scale
The Affect Reading Scale (ARS) (21) is a Swedish test of empathy designed for persons aiming at careers in the helping professions, being a direct test of it, whereas the other two tests involve self-evaluation.

Interpersonal Reactivity Index
Two of the subscales of the Interpersonal Reactivity Index (IRI) (22) were utilised: the Perspective Taking Scale and the Empathic Concern Scale.

Social Skills Inventory
A Swedish translation of the Social Skills Inventory (SSI) (23, 24, K.R. Kulich, H. Bengtsson; unpublished data) was employed, only the total SSI score (global social skill) being used to predict participants’ behaviour.

Interviews with students
Each student admitted in 1996 and 1997 was interviewed by a teacher of the faculty. The interviews were of semistructured character, taking up various matters found relevant to dental training, such as motivation, social skills, ability to communicate, ability to reflect on things, sense of responsibility and certain physical characteristics (e.g. allergies, back
problems and colour blindness). Each interviewer was trained for the task, participating in a course in interviewing techniques led by a trained psychologist.

Each interview, which lasted approximately 45 min, was video-taped. To reduce potential subjective bias, interviewers were not provided either results of earlier testing or any academic or personal details concerning the students in question, only their names. Assessments by the interviewer, both of certain specific matters to be noted and of the candidates’ overall suitability, were each made on a three-step scale, the lowest value representing adjudged lack of suitability.

**Criteria for study success**
The point scores and assessments the selection instruments provided were correlated with various measures of study success. Temporary interruptions of studies, repetitions of course work and dropout rates were also analysed, as a rather high attrition rate had been noted at the School for several years. None of the teachers that a candidate had in the course of his/her studies, except possibly for the one conducting the interview, had any knowledge of the student’s individual test results.

Four criteria or sets of criteria for study success were employed:
1. ***Number of courses failed.*** As there were certain differences between groups of students in the number of courses taken for which examinations were required, an adjustment was made so that the groups would be comparable: dividing the number of courses failed by the number of courses taken for which exams were required.
2. Results on a pre-clinical course in operative dentistry.
Here, a grade scale rather than the conventional
pass/fail system was employed for evaluation
purposes.
3. Temporary breakoff of studies, repetition of a term’s
course work and dropouts. Note was made of the
reasons for any temporary breakoff of studies and
for dropouts.
4. Social competence and empathy. Assessments of these
were made by tutors and clinical supervisors, use
being made of three separate scales which were
developed:

Interpersonal competence in a group situation
Tutors rated the ability of participants to express
themselves verbally, cooperate with others, and con-
tribute constructively to problem solving in their
study group. Each of these three separate aspects of
interpersonal competence was rated on a 1 (low) to 4
(high) scale. The combined variable based on all three
had a reliability (Cronbach alpha) of 0.88.

Ability to profit from support by the supervisor
Clinical supervisors rated the ability of participants to
communicate their problems, to listen to the supervi-
sor’s comments, and to react constructively to criti-
cism. Each of these three aspects of being able to profit
from the supervisor’s support was rated on a 1—4
(low—high) scale. The variable combining the three
had a Cronbach alpha of 0.89.

Interaction with patients
A scale to be used by clinical supervisors in assessing
how closely a student’s interaction with patients
matched a derived prototype of professional beha-
viour was developed. The prototype, taken from Holm
(25), was defined operationally in terms of 14 variables
dealing with such matters as treatment atmosphere,
respect for the individual, empathy, flexibility, com-
munication and initiative. Clinical supervisors rated
students’ behaviour on each variable using the categ-
ories ‘fits to a high degree’, ‘fits to a certain extent’ and
‘does not fit at all with observations.’ The total score
for professionalism in interaction with patients had a
Cronbach alpha of 0.85.

Statistical methods
The results are reported largely in terms of correlation
coefficients (Pearson \( r \)) and regression analyses, and
occasionally two-tailed \( t \)-tests, using the statistics
software StatView (with an upper limit of \( P = 0.05 \)).
The number of observations upon which the correla-
tions are based is reported for each pair of variables
involved, being placed in parentheses when it appears
in the text. For the correlation coefficients found to be
statistically significant, the convention suggested by
Cohen (26) of describing correlations of about 0.10 as
being low, of about 0.30 as being medium in size, and
of about 0.50 as being large has been followed.

Results
Relations of the prediction and criterion variables
to sex and age
The male and the female participants did not differ
significantly (two-tailed \( t \)-tests) on any of the variables
studied. Both cognitive ability and self-rated social
skills (SSI) were found to decrease with age. For SSI,
\( r(82) = -0.45, P < 0.001 \). The results for some of the
other variables, including those of cognitive ability,
are shown in Table 1. Only for Manual Speed and
Accuracy was a significant increase with age obtained.

Prediction of course failure
We expected that certain of the tests of cognitive and
manual abilities, as well as the global assessment
based on the interview, could serve as predictors of
failures in course work. The relations of these various
predictors to each other will be reported first.

The highest correlation found, \( r(177) = 0.69, P < 0.001 \),
is between the two tests of spatial ability. The test of general intelligence (Matrices), in turn,
correlates strongly with the most difficult spatial test

<p>| TABLE 1. Correlations between predictor variables and number of course failures/number of courses for which exams were taken (CF), results on a course in pre-clinical operative dentistry (POD) and age |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|</p>
<table>
<thead>
<tr>
<th>Matrices</th>
<th>Folding</th>
<th>Tin Models</th>
<th>Cavity Reprod.</th>
<th>Manual Speed &amp; Accuracy</th>
<th>Interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF</td>
<td>0.32***</td>
<td>0.29***</td>
<td>0.34**</td>
<td>0.06</td>
<td>-0.25*</td>
</tr>
<tr>
<td>n</td>
<td>152</td>
<td>185</td>
<td>176</td>
<td>78</td>
<td>77</td>
</tr>
<tr>
<td>POD</td>
<td>0.10</td>
<td>0.24**</td>
<td>0.27**</td>
<td>0.21</td>
<td>0.23</td>
</tr>
<tr>
<td>n</td>
<td>98</td>
<td>131</td>
<td>121</td>
<td>51</td>
<td>50</td>
</tr>
<tr>
<td>Age</td>
<td>-0.18*</td>
<td>-0.30***</td>
<td>-0.28***</td>
<td>-0.09</td>
<td>0.22*</td>
</tr>
<tr>
<td>n</td>
<td>156</td>
<td>188</td>
<td>180</td>
<td>83</td>
<td>82</td>
</tr>
</tbody>
</table>

\( n \), number of persons involved.
\(*P < 0.05, **P < 0.01, ***P < 0.001 \).
(Folding), \( r(153) = 0.51, P < 0.001 \), to a somewhat lesser degree with Tin Models, \( r(83) = 0.38, P < 0.001 \), and to a still lesser though still significant degree with Cavity Reproduction \( r(83) = 0.23, P < 0.05 \). The remaining correlations that are significant, those of the two spatial tests with Cavity Reproduction and with the global assessment made in the interview, are of intermediate strength (0.29—0.35).

Difficulties of a student in succeeding in his/her studies is reflected by CF, the quotient of the number of course examinations failed to the number taken. The correlations between CF and the other variables are shown in Table 1. As can be seen, all the predictors except for Manual Speed and Accuracy correlate significantly (all negatively) with CF, whereby the two spatial tests and Cavity Reproduction correlate moderately with it, Matrices and the assessment in the interview correlate to a lesser degree. To determine what combination of the predictor variables is most strongly related to CF, a stepwise multiple regression analysis using CF as the dependent variable (based on 76 individuals, as in an analysis of this type a measured value on each of the variables needs to be available for all of the individuals involved) was then carried out. A significant relationship to CF was found for the combination of Folding and Cavity Reproduction only: \( r = 0.44, P < 0.001 \).

Prediction of results on a pre-clinical course in operative dentistry

Table 1 also includes information on the extent to which success in a course in pre-clinical operative dentistry taken during the third semester could be predicted. Only the two spatial ability tests (Folding and Tin Models) showed a significant relationship with success in the course.

Prediction of dropout, temporary breakoff of studies and repetition of course work

Of the 90 students who began their studies in 1996 or 1997, there were 41 (46% of the two groups) who remained with their original group throughout and completed their studies at the time originally planned. This had little effect on the number of students in either group, however, due to students who had begun their studies earlier and temporarily broken them off resuming them, or of students who were forced to repeat a term being placed in one of the two groups.

The dropout rate was rather high, dropout frequently being preceded by an interruption of studies for one or more terms. A total of 28 dropouts (31%) occurred altogether, most of them taking place during the first four terms, particularly the second and third terms. An additional 21 students (23%) applied for a temporary interruption of their studies and returned to them after one or more terms, going on then to complete them. There were 11 students in addition (12%) who had to repeat the work of some terms after failing an examination.

Amongst the most common reasons for dropout were those of beginning studies for a medical degree instead, continuing dental studies elsewhere, going on with studies in some other academic area, personal reasons or reasons connected with the student not having qualified to go on with the work that would normally have followed the next term. Students who dropped out of the programme were thus by no means a homogeneous group. Accordingly, it was difficult to make predictions regarding them. Thus, comparing the 28 students who dropped out with the 54 students completing their studies for whom adequate data are available and who began at the same time reveals no significant differences between the two (two-tailed \( t \)-tests) in terms of the predictor variables.

Prediction of empathy and of social competence

Possibilities of predicting the degree of social competence students would show in contacts with their fellow students, their supervisors and their patients were investigated, using as predictors their results on the Social Skills Inventory and on the empathy tests, how they were evaluated in the interview and their results for general intelligence level (Matrices). Examining first how the various predictors were related to each other revealed (i) that participants with higher self-ratings of social competence (SSI) tended to be evaluated more positively in the interview, \( r(78) = 0.24, P < 0.05 \), and to score higher on the ARS, \( r(82) = 0.23, P < 0.05 \), and (ii) that the two measures of self-reported empathy (empathetic concern and perspective taking, IRI) correlated positively with each other, \( r(82) = 0.33, P < 0.05 \), but were not related significantly to scores on the ARS.

Next we examined how the three criterion variables for social competence were related to each other. Because some of the participants either broke off their studies temporarily at some point or dropped out, not all had been evaluated by their tutors and supervisors the same number of times. This problem was dealt with by basing the statistical analysis on the average evaluation each participant had received.

The three measures of social competence for the students whilst engaged in their studies were found to be highly correlated. The tutors’ evaluations of the
interpersonal competence of the students in their interactions with others in the group were found to correlate positively with the evaluations the students’ supervisors had made of their ability to profit from the advice they received, \( r(51) = 0.65, P < 0.001 \), and of their interaction with patients, \( r(57) = 0.65, P < 0.001 \). These two evaluations by the supervisors were also highly correlated with each other, \( r(51) = 0.83, P < 0.001 \).

The evaluations of the students’ social competence by the tutors and by the supervisors could not be predicted, on the contrary, on the basis of the students’ assessment of their own social competence (SSI) or of their empathetic ability (IRI). However, a positive relationship was found between empathy as measured by the ARS and the tutors’ assessments of the students’ social competence generally, \( r(53) = 0.40, P < 0.01 \), of their interpersonal competence whilst being advised, \( r(48) = 0.29, P < 0.05 \), and of their contact with patients, \( r(53) = 0.30, P < 0.05 \). The students’ social behaviour during their programme of studies could also be predicted from how they were evaluated in the interview, a positive evaluation there being related to a positive assessment of their interpersonal competence in meetings with their supervisor, \( r(49) = 0.31, P < 0.05 \), and of their contact with patients, \( r(54) = 0.30, P < 0.05 \). A positive relationship was found as well between general level of intelligence and adjudged level of professionalism in contacts with patients, \( r(56) = 0.27, P < 0.05 \).

To determine whether any combination of predictor variables would be more closely related to the behavioural assessments made than any single predictor variable, three stepwise regression analyses were carried out, one for each of the criterion variables. There was no appreciable increase in the strength of the relationship obtained when any of the possible combinations of predictor variables were employed when compared with use of the individual predictor variables.

**Discussion**

The investigation concerned the extent to which certain variables can predict study success in a 5-year programme of training in dentistry. The aim was to develop as effective methods as possible for the selection of students. As the predictive measures were not used for selection purposes, criterion measures pertaining to study success could be obtained for all participants – also for those with low scores on the predictive measures. On the contrary, one can have certain doubts of whether students who had already been selected took the selection tests in a completely serious way. Their failure to do so would probably increase the error variance of the predictive measures and thus attenuate the correlations.

**General intelligence**

Extensive research has shown that success in a wide variety of working tasks and educational programmes correlate positively with general intelligence (1, 2, 27). The Matrices test can be seen as providing a measure of general intelligence relatively independent of a person’s level of experience, knowledge and training. The significant correlation of scores on that test with both the number of courses failed and the ratings of students’ interaction with their patients are thus fully in line with the results of earlier studies. Why are the correlations not higher, however? One reason can be that relationships between intelligence and academic performance tend to diminish in size higher up in the educational system, due to selection factors decreasing the variance in level of intelligence found.

It should be emphasised that the aim of a test is not in any sense to explain all the variance involved in performance, but rather to explain insofar as possible the part of the variance one cannot explain by use of other instruments. A test of general intelligence can thus be expected to explain the variance associated with one of the factors important to study success, not all such factors. Thus, the advantages that high intellectual capacity provide can be lost if the approach a student takes is not conducive to success, and the disadvantages of only moderate intellectual capacity can only partly be compensated for by a high level of motivation (3).

**Spatial ability and manual dexterity**

For a dentist, it is probably important to be able to grasp readily both spatial relationships and the effects which various spatial and structural changes would have. Not surprisingly, spatial ability has frequently been found to be related to dental school performance. It has also proved to be a strong predictor of psychomotor learning (see 15). In the present study, tests of spatial ability were found able to predict examination results in a pre-clinical course in operative dentistry. The number of examinations failed could also be predicted to a significant extent on the basis of these tests. This indicates the particular importance for a dental education which spatial ability has.

In both dental training and the practice of dentistry, a high degree of manual dexterity and the ability to...
perform exact and partly repetitive movements would appear to be advantageous. To varying degrees, Manual Speed and Accuracy (MSA) and Cavity Reproduction provide measures of this. The Cavity Reproduction test, however, differs from MSA in being concerned with both manual dexterity and spatial ability. It thus resembles rather closely the task with which the dental student and the dentist alike are faced (cf.28). Although Cavity Reproduction did not correlate significantly (MSA did not either) with success in the pre-clinical course in operative dentistry (note, nevertheless, the small number of persons involved), it was found to be negatively correlated to a moderate degree (which MSA was not) with the number of examinations failed. This suggests the spatial factor rather than manual dexterity to be what Cavity Reproduction measures primarily.

Interviews
The use of an interview as a selection instrument has been described in both positive and negative terms (16, 29–35). In the present study, significant correlations were found between results of the interview and the number of course examinations students failed. We were not able to confirm findings others have reported of dropout being possible to predict in interviews (16, 36). Differences between various studies in the usefulness which interviews have been found to have for admission purposes may be related in part to differences in the interview procedures involved. It is often maintained that structured interviews provide the best predictions (35, 37). The reason for our choosing a different type of interview was that the interview was to be used in conjunction with a number of specific tests of homogeneous, rather clearly defined characteristics. It was regarded as providing information complementing the test results, enabling certain factors to be assessed that could be of relevance for many different aspects of dental training. We hoped that both the explicit and implicit knowledge which the teachers had of such factors would be of considerable help here. The results suggest this to have been the case. However, there are many questions yet to be answered regarding the reliability, predictive validity and cost-effectiveness of such interviews (cf.5).

Clinical performance
Successful clinical performance on the part of a dental student requires that he/she possess a variety of cognitive abilities that interact with complex non-cognitive variables involving not only the student, but also of the patient and the supervisor (38). The ratings of the students by their clinical supervisors could be predicted to a significant degree on the basis not only of the interviews, but also of general intelligence and of empathetic capacity as assessed by the ARS. Our results are in line with earlier findings indicating the individual’s behaviour in a test situation of this type to yield information indicative of how he/she would function in a care-providing profession (21). An assessment of the individual’s social ability can also be made in the interview situation, social behaviour being required of the person in concrete terms there. Such assessments of social ability were found able to predict individual differences in the social behaviour of the students in the course of their studies. The students’ self-reports of their empathy and social skills, on the contrary, could not be used to predict the assessments of their social behaviour during their studies by their supervisors and tutors. Tests that involve the person who is being tested providing a self-description can thus be problematical in a selection-type situation. The validity of self-assessments is affected both by one’s degree of self-insight and one’s willingness to provide an honest picture of oneself.

Dropout
It was not possible to predict the occurrence of dropouts on the basis of the test combination and the interview employed, probably because of the dropouts having such a variety of causes. As has been found generally for both dental and medical school programmes (e.g.16, 39–44), dropouts here occurred primarily during the first four terms and particularly at the end of the second and third terms. This was presumably due, in part, to those involved discovering rather early that their choice of dentistry was not right for them.

The dropout rate was also high, 31% in the two student groups as a whole, but was still about the same as earlier, during the 1990s. For comparison, previously reported dropout rates, although varying, have usually been at a definitely lower level (39, 40). In the present study, an explanatory factor could be that during the 1990s the career possibilities in Sweden for dental students appeared to have worsened. In the last few years, however, the situation has improved and in 2001 the early dropout rate had clearly declined. Thus far, only two students from that group have dropped out, a matter that will be followed up as the students continue their education.

A possible admissions model
One should note that the practical value of a predictor is a function not only of the size of its correlation with
a criterion (i.e. of its validity), but also of the selection ratio, which is the proportion of applicants who are selected. If the selection ratio is small, use of tests or other predictors of even relatively low validity may provide fully acceptable results. Just the opposite can be the case if the selection ratio is large. If one is forced to accept nearly all applicants, use of a highly comprehensive selection procedure which is highly demanding of time and other resources can be a waste of resources.

With some few exceptions, the tests we used were already standardised ones available commercially. Thus, they can be used by any accredited psychologist or accredited test user who wants to make direct use of the findings of the study. Particular advantages of the Folding and the Tin Models tests are that they require little time to complete and, just as in the case of the Matrices test, can be scored in a quick and objective way by use of scoring sheets and the like. Both the material costs of such tests and the costs of administering them are low, whereas an interview is much more demanding of resources. These are important matters to consider in deciding what selection procedures to employ.

In making practical use of the present results, one also needs to create or adopt a satisfactory model for giving the different predictor and criterion variables appropriate weights. Since 2001, about half of the students admitted to studies at the Dental School in Malmö have been selected by use of an individual admissions procedure, one based on the results reported here. The results of the Folding, Tin Models, Raven Advanced Progressive Matrices (which replaces the Matrices test used in the present study) and Cavity Reproduction tests and of the interview are given equal weights through transformation of the raw scores into standard scores (M = 0, SD = 1). The students are ranked then in accordance with the sum of these standard scores. Those ranked highest are accepted, provided they are not regarded as clearly unsuitable on the basis of their results on an empathy test which is not of the self-report type. The model employed will be evaluated by comparing students accepted in the traditional way with those accepted on the basis of these tests and of interview.

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