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Psychometric Assessment of Computing Undergraduates

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Abstract. This paper describes three studies of students in computer science, information technology, and software engineering degree courses. *Aim.* The aim of these studies was to evaluate the usefulness of aptitude testing as a means of recruiting undergraduate students into these courses. *Method.* At the start of the academic year, student volunteers were invited to complete a demographic survey and/or part of the Aptitude Profile Test Series (APTS) developed by the Australian Council for Education Research. At the end of the year, the survey and APTS data were combined with examination results, and a statistical analysis was performed. *Results.* The demographic survey yielded several potential predictors of academic performance. Furthermore, the APTS was a statistically significant predictor of academic performance ($p < 0.001$). *Conclusions.* The results suggest that the APTS could be used to recruit students into computing degree courses, reducing the withdrawal and termination rates, and increasing the number and quality of graduates from these courses.

1. Introduction

Aptitude tests are commonly used in career guidance and personnel selection [1]. Unlike academic tests, the questions in an aptitude test are not based on curricular content. Instead, they assess more generic aspects of cognitive ability. For instance, the Computer Programmer Aptitude Battery (CPAB) published by Palormo and Fisher in 1964 [2] is an early example of an aptitude test, consisting of five components that examine various cognitive aspects of computer programming.

This paper investigates the use of an aptitude test within the Department of Computing at Curtin University of Technology, the largest university in Western Australia. The aim of this work was to evaluate the usefulness of aptitude testing as a means of selecting students for admission into computing degree courses. The Department of Computing is one of the most successful at Curtin, both in terms of the number and quality of its graduates, and the cultural diversity of its staff and students. The Department offers degrees in Computer Science (CS), Information Technology (IT), and Software Engineering (SE), as well as several double degrees with other departments [3]. Using an aptitude test for course recruitment could help to reduce the number of students who withdraw, are terminated, or otherwise leave these courses before graduation. This in turn would increase the number and quality of graduates. Furthermore, aptitude testing could benefit students by helping them to make informed career choices.

Section 2 briefly reviews previous work on psychometric assessment of students in tertiary level computing courses. Section 3 describes the method, including a demographic survey and the aptitude test used in this work; Section 4 describes the results of three studies of first-year and second-year students using these instruments. Finally, Sections 5 and 6 discuss the results, draw some conclusions, and outline directions for future work.

2. Background

Over the last 40 years many studies have attempted to predict aptitude in computer science. For example, Konvalina et al. (1983) examined a sample of 382 students in a first subject in computer science [4]. The students were given a test consisting of 25 logic, calculation, algorithmic and verbal algebraic exercises. At the end of the subject those students who remained tended to be more proficient in mathematics than those who withdrew. This finding lead to the test being used for recruitment purposes, and the withdrawal rate fell from 40% to 23%.

Another typical study from this decade, by Campbell and McCabe (1984), used SAT mathematics and verbal scores, high school mathematics and science marks, class ranking, and gender of 256 first semester computer science majors as predictors of academic performance [5]. Results indicated that students who continued with computer science had achieved higher SAT mathematics and verbal scores, completed more mathematical or scientific subjects in high school, and had a higher rank in class than those who did not continue with the course. In a similar study of 269 first semester students Butcher and Muth (1985) also suggested that mathematical proficiency was an important factor in succeeding at computing subjects [6].

More recently, Byrne and Lyons (2001) categorised 91 humanities students in a first-year programming subject according to one of four learning styles: Diverger, Assimilator, Converger or Accommodator. The results were analysed against gender, prior experience, and previous academic performance in mathematics, sciences and languages. The majority of students were found to be Convergers and this group also performed best. This learning style is best used for 'finding practical uses for ideas and theories' with strengths in 'problem solving, decision making, deductive reasoning and defining problems'. Successful students were also proficient in mathematics and science with statistically significant correlations; however, previous programming experience did not have a noticeable impact on performance [7].

In another recent study, Wilson and Shrock (2001) took questionnaire responses and self-efficacy scale measurements from 105 students learning C++ [8]. The scale measured confidence in performing C++ related tasks. Questionnaire items included gender, mathematical background, previous experience with computers, external influences to studying computer science, and comfort level in the course. Based on results from a mid-term examination, the authors found that comfort level was a primary factor in success, followed by mathematical background.

The common findings in these and other studies are that mathematical and scientific training, and various demographic and psychological characteristics, are predictors of success in computing subjects. However, the majority of studies like this occurred over ten years ago. The last decade has seen a paradigm shift from structured programming to object-oriented design. Likewise, software engineering has begun to mature as a discipline, with many universities introducing SE degrees in the last few years. Given these developments, a new study could yield valuable new information for academics and students alike. The next section describes an attempt to explore some of the themes from these studies, using Australian undergraduate computing students and a modern aptitude test.

3. Method

This section describes the method and instruments used in three related studies of first- and second-year undergraduates in CS, IT and SE. The same basic method was employed for each study, though modifications were necessary in each case. Subsections 3.1 and 3.2 describe the instruments used in these studies. Subsection 3.3 describes the administration of each study.

3.1 Aptitude Profile Test Series (APTS)

The main criterion for selecting an aptitude test was that it should measure at least some of the psychological characteristics identified in the background section, such as mathematical or abstract reasoning ability. Additional criteria were the availability, ease of administration, and cost of the instrument. For aptitude testing of large numbers of students to be feasible, the test must be inexpensive, and quick and easy to administer. The test must also be from a reputable source, with information about its development readily available. The Aptitude Profile Test Series (APTS) [9] was therefore chosen. This test is available from the Australian Council for Educational Research (ACER).

The APTS consists of verbal, quantitative, abstract and spatial-visual reasoning tests as shown in Table 1. Each test can be administered independently, or in combination with any of the others. Furthermore, each test consists of multiple parts that are separately timed, so the parts can also be administered separately. Each test takes 45 minutes to administer in full (30 minutes per test, plus 15 minutes for instructions). Given the reliance on unpaid student volunteers for this study, it was decided to combine parts from two tests into a single testing session lasting approximately one hour.

Table 1. Description of the Aptitude Profile Test Series

Test	Skills Assessed	# Parts
Verbal	Vocabulary, verbal analogy and comprehension.	4
Quantitative	Ability to solve arithmetic & algebraic problems.	3
Abstract	Ability to identify, complete or extend patterns.	2
Spatial-Visual	Ability to visualize and manipulate objects and views.	3

The verbal and quantitative reasoning tests are predominantly made up of written questions, whereas the abstract and spatial-visual reasoning tests are predominantly pictorial. One test of each type was chosen: the Abstract Reasoning test and the Quantitative Reasoning test. The Quantitative Reasoning test requires subjects to solve abstract numeric and written mathematical problems. In contrast, the Abstract Reasoning test requires subjects to identify rules that underlie abstract patterns, and to use these rules to extend the patterns. Due to the limited time available, only the first two parts of the Quantitative Reasoning test (48 questions), and the first part of the Abstract Reasoning test (20 questions), were used.

3.2 Demographic Survey

A short demographic survey was created, based on the main themes identified in the literature review. The survey items are listed below, along with the reasons for their inclusion. The last two items were ‘wild cards’ included simply because the authors thought that they might yield interesting results. For more information see Ong [10].

Student Number. Unique student numbers are assigned to students when they first enrol at Curtin. These were used to associate academic records with aptitude test results. No other identifying information was used, so that participation in the studies was essentially anonymous.

Date of Birth, Gender. These items were included to describe the sample and to characterize the diversity of the students.

Country of Birth, First Language. The APTS was standardized for an Australian population, and so might be biased against non-native English speakers. It was therefore important to know which students might be affected.

Number of Science / Mathematics Subjects in High School. The literature review identified mathematical background, and to some extent scientific background, as predictors of success. Students were also asked whether they had Studied Calculus, because this is arguably the most intellectually challenging subject taught in Australian high schools.

Previous Experience in Computing. Some students take computing subjects at high school (e.g. TEE Information Systems). Such experience might give students an advantage in a tertiary level CS, IT or SE degree. Students were also asked to list all the Programming Languages Known to them before starting university. In the data analysis the term ‘programming languages’ was broadly interpreted to include mark-up languages like HTML.

Part-Time Employment. Experience in the workforce, and the resulting development of life skills, might be an advantage in an educational environment?

Musical Ability. Students who are able to learn a musical instrument might be able to learn to program more easily. Skills such as software design are as much art as science, so perhaps demonstrated musical ability might improve such skills?

3.3 Administration and Data Collection

The APTS was administered according to the instructions specified by Morgan et al [9]. Participation in the studies was voluntary, and ethical clearance was obtained from the appropriate University committee beforehand. All participants were fully informed of the nature and purpose of the study.

The academic records of all participants were subsequently obtained from the University administration. All identifying information on the records was removed except the student number, which was necessary to link the records to the APTS and survey results. Only core subjects in the CS, IT and SE degree courses were used to analyse academic performance. The final mark from each student in every core subject was recorded. Only the mark from the first attempt was used; subsequent attempts were ignored. As in most computing departments these subjects have undergone extensive revision over the last few years, so only current versions of subjects were included in the analysis. Previous versions, equivalent subjects, and advanced standing were not included. This explains the different values of N (sample size) in the results that follow.

Students who had withdrawn or been terminated were excluded from the dataset because no marks were available for them. If a student was awarded a DNC grade for a subject then the associated mark was included in the dataset. DNC is the grade given to students who *Did Not Complete* all of the assessment necessary to achieve a passing grade. A DNC will always result in a mark, usually a low one, and typically indicates that a student stopped attending classes without formally withdrawing. These students account for the low outliers in the results.

Study 1. A pilot study was conducted on first-year student volunteers in semester one of 2003.[1] Information about the study was provided during course enrolment and orientation sessions. However, most students declined to participate, typically stating that they did not have time, did not perform well in test situations, or did not like the idea of taking an aptitude test. There were just 34 volunteers (8.9%) out of approximately 380 first-year students. Although this response rate is not unusual for a study requiring volunteers to spend an hour taking a test, it did not provide a sufficiently large sample for an in-depth statistical analysis. As a result, it was decided to use a short demographic survey to obtain more information about the reluctant students.

Study 2. A demographic survey of first-year students was conducted at the end of a lecture in a core subject (ST151) common to the CS, IT and SE courses. Conducting the survey in a lecture guaranteed that a large number of students would be present, yielding a better representation of the student population than in Study 1, and therefore more accurate relationships between demographics and academic performance. There were 214 volunteers (56.3%) out of approximately 380 first-year students.

Study 3. The poor response rate in Study 1 suggested that there was little chance of getting more first-year volunteers for the APTS. However, many of the second-year students had expressed interest after seeing advertisements for the study on notice boards. A new study was therefore conducted using these students to investigate the relationship between APTS score and academic performance. There were 80 volunteers (47.9%) out of 167 second-year students.

1 In Western Australia the academic year typically begins early in March and ends late in November, and is divided into two semesters each lasting 18 weeks with a gap of about four weeks in between.

4. Results

The results from each of the three studies are presented in the subsections that follow. The results from Study 1 are not examined in detail because of the small sample.

4.1 Study 1: First-Year APTS

Demographics. Of the 34 volunteers for this study, one was removed from the sample because they were not enrolled, and two did not complete the aptitude test. Of the remaining 31 students, four were female and 27 were male, all between the ages of 18 and 33 with an average age of 21 years.

Academic Performance. In first year, first semester, the only subject common to all three computing degrees is Software Technology 151 (ST151), which introduces object-oriented design and programming in Java. Australian students performed significantly better in this subject than those from overseas (t = 2.805, df = 28, p = 0.009). Furthermore, students who worked part-time performed significantly better than those who did not work (t = 2.952, df = 28, p = 0.006). [2] Note that three students are missing from this analysis because they were given exemptions from ST151. There were no other statistically significant differences in academic performance based on demographic characteristics. These findings are examined in more detail in Studies 2 and 3.

APTS as a Predictor of Academic Performance. There was a statistically significant positive correlation between APTS score and performance in ST151 (N = 28, Pearson = 0.401, p = 0.028).[3] This finding is examined in more detail in Study 3.

4.2 Study 2: First-Year Demographic Survey

Demographics. A total of 214 first-year students completed the demographic survey. However, ten students did not provide valid student numbers, and another seven later withdrew from their courses. After eliminating these students, a total of 197 students remained in the sample. The youngest participant was 17 and the eldest 42 (average age 20). A summary of the demographic characteristics of these students can be seen in Table 2.

Academic Performance. Table 3 summarizes the academic results obtained by the first-year students, by course and by subject. A few students are missing from each row of the table due to exemptions or withdrawals. Also, the SE course does not include the subject FCS151, which covers Fundamentals of Computer Science such as number representations, logic and operating systems. Given the aim of this work, it is interesting to note that the mean score of all students combined, and of the IT students in particular, was below the 50% pass mark in both of the core first-year units.

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[2] Academic performance based on Country of Birth: Australia (N = 14, mean = 59.2, SD = 13.89); Other (N = 14, mean = 41.8, SD = 19.60). Academic performance based on Part-Time Work: Yes (N = 11, mean = 61.6, SD = 11.44); No (N = 17, mean = 43.1, SD = 19.49).

3 Pearson correlations indicate the strength of a linear relationship in data – values greater than 0.25 or less than –0.25 are statistically significant.

Table 2: Summary of demographic characteristics of first-year students

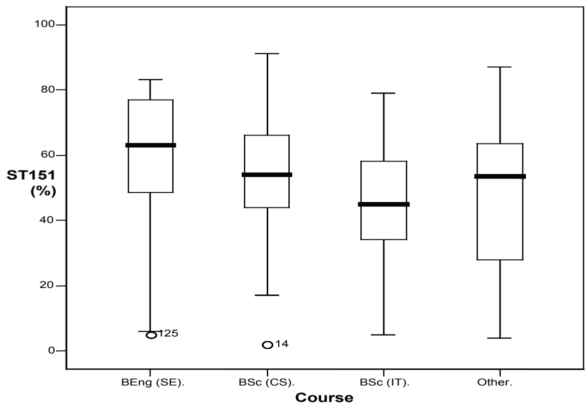
Demographic	Valid Responses		Missing
Gender	Male: 168 (85%)	Female: 29 (15%)	-
Country of Birth	Australia: 104 (53%)	Other: 93 (47%)	-
First Language	English: 130 (66%)	Other: 67 (34%)	-
Studied Calculus	Yes: 115 (58%)	No: 70 (36%)	12 (6%)
Previous Experience	Yes: 127 (64%)	No: 69 (35%)	1 (0%)
Paid Work	Yes: 83 (42%)	No: 111 (56%)	3 (2%)
Musical Ability	Yes: 92 (47%)	No: 104 (53%)	1 (0%)

Table 3. Summary of academic results of first-year students by course and by subject

Degree Course	Subject	N	Min	Max	Mean	SD
BSc (IT)	ST151	54	5	79	44.7	18.39
	FCS151	54	4	78	40.7	20.45
BSc (CS)	ST151	45	2	91	53.0	17.64
	FCS151	46	1	79	49.7	22.71
BEng (SE)	ST151	20	5	83	58.6	22.37
	FCS151	-	-	-	-	-
Other	ST151	51	4	87	48.3	23.07
	FCS151	52	0	83	48.4	24.01
All Degrees	ST151	189	2	91	49.5	20.62
	FCS151	164	0	83	45.9	22.40

Figure 1 shows that the mean ST151 result for SE students was higher than for CS students, which was higher than for IT students. A one-way ANOVA confirmed that this difference between groups was statistically significant ($F = 5.378$; $df = 114, 2$; $p = 0.006$). This is probably a reflection of the higher entry requirements for the SE degree compared to the CS degree, and for the CS degree compared to the IT degree.

Figure 1. Differences between CS, IT and SE students in terms of performance in the first-year programming subject ST151



Demographics as Predictors of Academic Performance. Relationships were identified between academic performance and three demographic characteristics. There were statistically significant differences in academic performance based on Country of Birth ($t = 3.794$, $df = 195$, $p = 0.000$) and First Language ($t = 2.914$, $df = 195$, $p = 0.004$) as shown in Figure 2. This suggests that local students whose native language is English tended to perform better in the core subjects than those from overseas whose native language is not English. Furthermore, as shown in Figure 3, students who Studied Calculus in high school performed significantly better than others ($t = 1.971$, $df = 183$, $p = 0.050$).

Figure 2. (LHS) Academic performance based on Country of Birth: Australia (N = 104, mean = 52.9, SD = 21.08); Other (N = 93, mean = 41.6, SD = 20.49). (RHS) Academic performance based on First Language: English (N = 130, mean = 50.7, SD = 20.91); Other (N = 67, mean = 41.5, SD = 21.47)

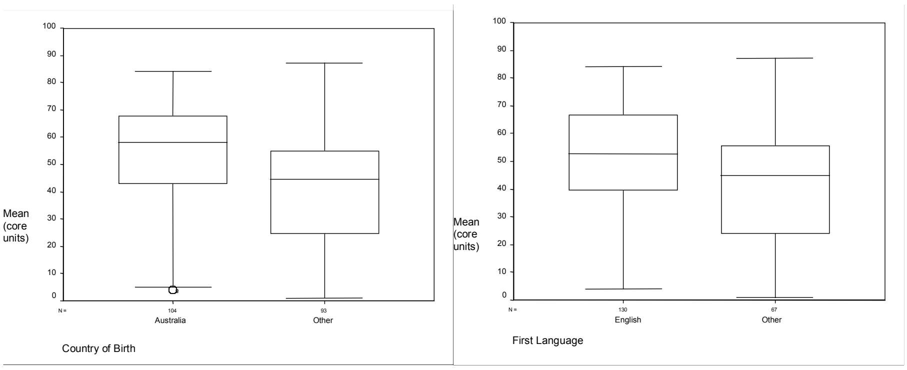
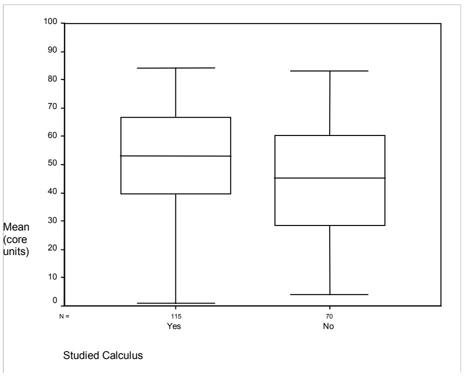


Figure 3. Academic performance based on whether students had Studied Calculus: Yes (N = 115, mean = 50.0, SD = 21.40); No (N = 70, mean = 43.6, SD = 21.42)



4.3 Study 3: Second-Year APTS and Demographic Survey

Demographics. A total of 80 second-year students volunteered for this study. One student was eliminated because he did not provide a student number. The final sample of 79 students contained 17 (22%) females and 62 (78%) males, all between the ages of 19 and 37 (average age 21). Table 4 summarizes the demographic characteristics of the sample. It is interesting to compare these characteristics with those of the first-year students in Table 2. The only obvious difference between the two samples is that the first-year students were more likely to have previous experience of computing subjects or programming. Perhaps this is a reflection of the evolving school curriculum in Western Australia?

Table 4: Summary of demographic characteristics of second-year students

Demographic	Valid Responses		Missing
Gender	Male: 62 (78%)	Female: 17 (22%)	-
Country of Birth	Australia: 33 (42%)	Other: 46 (58%)	-
First Language	English: 43 (54%)	Other: 36 (46%)	-
Studied Calculus	Yes: 47 (59%)	No: 25 (32%)	7 (9%)
Previous Experience	Yes: 24 (30%)	No: 54 (68%)	1 (1%)
Paid Work	Yes: 28 (35%)	No: 46 (58%)	5 (6%)
Musical Ability	Yes: 44 (56%)	No: 30 (38%)	5 (6%)

APTS Performance. A summary of the APTS scores is shown in Table 5. There is a wide distribution of scores even though the sample is taken from a population of second-year university students. Overall, students scored higher on Abstract Reasoning compared to Quantitative Reasoning. Figure 4 shows that the two APTS components are not significantly correlated (N=79, Pearson = 0.200, p=0.073). These findings agree with the test properties originally reported by Morgan et al [9].

Figure 4. Abstract (AR%) versus Quantitative (QR%) Reasoning scores of second-year students

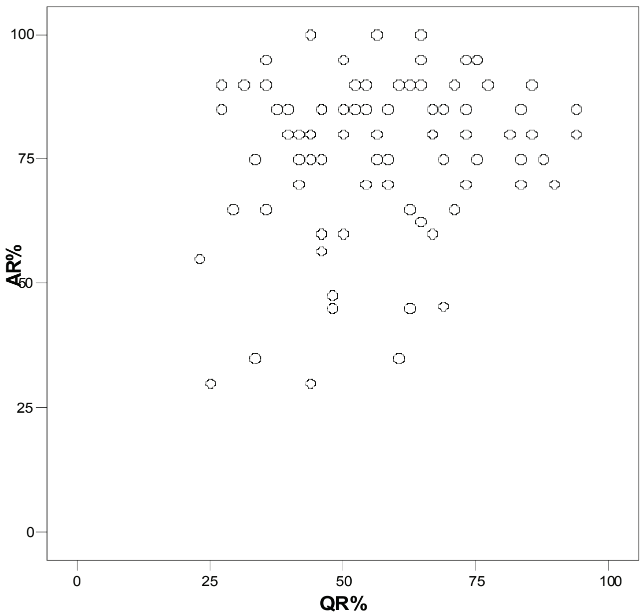


Table 5. Summary of APTS scores (as percentages) of second-year students

	N	Min	Max	Mean	SD
Quantitative	79	23%	94%	56.7%	8.43%
Abstract	79	30%	100%	76.5%	3.19%
Combined	79	27%	91%	62.4%	9.54%

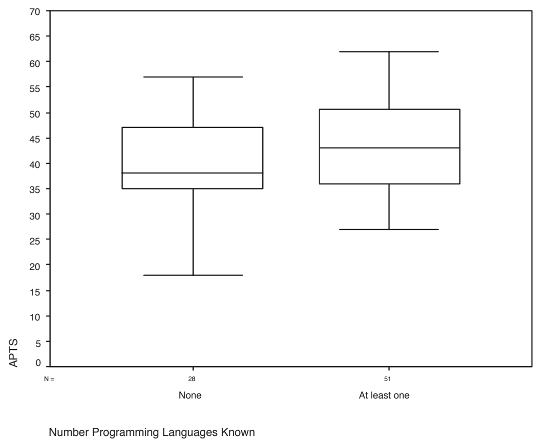
Academic Performance. Table 6 shows a summary of the academic results. Shaded rows show common core subjects for the CS, IT and SE degrees. FCS151, FCS152 and SPD251 are not core subject in the SE degree. FCS152 and DAA251 are not core subjects in the IT degree. The standard deviations for first-year subjects (ending with 151 or 152) are generally higher than for second-year subjects (ending with 251). This suggests that students perform more consistently in assessments as they progress through university. On the other hand, the large differences between means suggest either that some subjects are inherently more difficult than others, or that different lecturers maintain different standards in different units. For example, compare ST152, which is essentially a programming subject, with DAA251, which is essentially a mathematical subject. The same lecturer taught both subjects in 2003.

Table 6. Summary of second-year academic results

Subject	Code	N	Min	Max	Mean	SD
Software Technology 1	ST151	72	16	96	67.0	17.76
Foundations of Computing 1	FCS151	69	21	94	60.0	13.87
Software Technology 2	ST152	69	4	88	66.3	15.29
Foundations of Computing 2	FCS152	48	15	83	62.7	13.57
Introduction To C Programming	IPE152	67	30	89	60.7	12.70
Design & Analysis of Algorithms	DAA251	39	20	82	53.6	13.90
Software Engineering	SE251	79	17	87	64.2	13.76
Systems Programming & Design	SPD251	47	12	79	57.7	11.67
	Average:	79	35.0	85.3	61.6	12.29

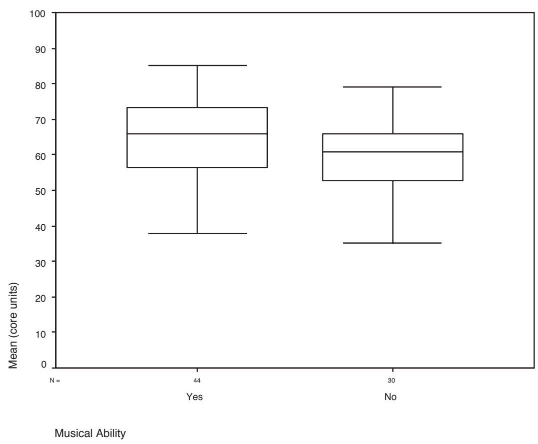
Demographics as Predictors of APTS Score. The only demographic that produced a statistically significant difference in APTS scores was Previous Experience in Computing ($t = -2.126$, $df = 77$, $p = 0.037$). Students who knew at least one programming language prior to university performed better overall than those who knew none, as shown in Figure 5.

Figure 5. APTS scores based on Number of Programming Languages Known: None (N = 28, mean = 39.4, SD = 9.86); At Least One (N = 51, mean = 44.1, SD = 9.04)



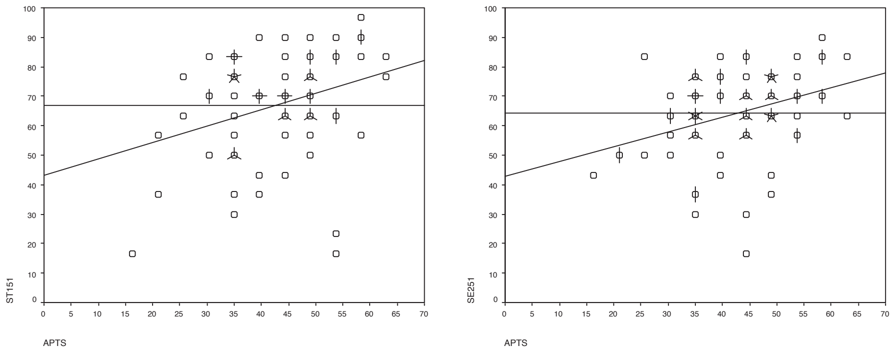
Demographics as Predictors of Academic Performance. A comparison of different demographic groups yielded only one statistically significant difference in overall academic performance, based on Musical Ability. Musical students performed significantly better overall in core units (t = 2.203, df = 72, p = 0.031) as shown in Figure 6.

Figure 6. Overall academic performance based on Musical Ability: Yes (N = 44, mean = 64.8, SD = 11.85); No (N = 30, mean = 58.8, SD = 11.01)



APTS as a Predictor of Academic Performance. There was a statistically significant positive correlation between aptitude and academic performance (N = 79, Pearson = 0.399, p < 0.000.). Students with high APTS scores tended to have better academic results than students with low APTS scores. The correlation is strong enough to appear in data for individual subjects. For example, Figure 7 LHS shows that APTS score has a statistically significant correlation with performance in ST151 (N = 72, Pearson = 0.305, p = 0.009). Figure 7 RHS shows that APTS score has a statistically significant correlation with performance in SE251 (N = 79, Pearson = 0.350, p = 0.002). These subjects are important because they are the first to introduce object-oriented programming (ST151) and software engineering (SE251).

Figure 7. APTS scores as a predictor of ST151 results (LHS) and SE251 results (RHS). The horizontal lines show the mean results for all students in the sample. The diagonal lines show the approximate relationships between APTS and academic performance.



5. Discussion

5.1 Study 1: First-Year APTS

This study was limited by the small sample size: only 31 students. Nevertheless, the APTS appeared to be a predictor of academic performance in the first-year programming subject ST151. In addition, Australian students appeared to perform better than those from overseas, and students who worked part-time appeared to perform better than those who did not work. However, because of the small sample it was necessary to carry out two additional studies to explore these preliminary findings.

Most of the problems in this study arose from the difficulty in recruiting first-year students. Many were reluctant to volunteer, stating reasons that suggested lack of interest, motivation or self-confidence. This poor response is particularly interesting given the willingness of second-year students to participate. Presumably second-year students are beginning to think seriously about their employment prospects and so welcome an opportunity to take an aptitude test similar to those used for recruitment? Furthermore, second-year students are presumably more relaxed and confident in a university environment than first-year students, particularly at the beginning of the academic year?

5.2 Study 2: First-Year Demographic Survey

This study of 197 first-year students provided an opportunity to explore whether demographics had an effect on academic performance. There were two main findings relating to cultural and mathematical background.

First, there were statistically significant differences in academic performance based on Country of Birth and First Language. This suggests that overseas students whose native language is not English are at a disadvantage. Students require a vocational level of English to enrol at Curtin, as determined by a standardized English test. One explanation for the apparent bias against overseas students may lie in the validity or reliability of that test. It may be necessary to employ another method of evaluating English competency in future.

Second, academic performance was dependent on whether or not students had Studied Calculus. This finding is similar to those of previous studies, which suggest that mathematical ability is a predictor of performance in computing courses.

5.3 Study 3: Second-Year APTS and Demographic Survey

This study of 79 second-year students was intended to evaluate the APTS in more detail than was possible in Study 1. Only three statistically significant relationships were identified.

First, students with Previous Experience in Computing tended to score higher on the APTS than inexperienced students.

Second, students with high APTS scores tended to perform better academically than those with low scores. This confirms the finding in Study 1 that the APTS is a predictor for academic performance in computing. The statistically significant correlation is particularly encouraging given that it was only possible to administer the first two parts of the Quantitative Reasoning test, and the first part of the Abstract Reasoning test. According to Morgan et al [9] using whole tests rather than individual parts should increase the accuracy of the APTS scores. This in turn should lead to better prediction of academic performance.

Third, and perhaps most surprising, students with Musical Ability tended to perform better academically than those who did not play a musical instrument. This relationship can be interpreted in a number of ways. Perhaps the ability to play a musical instrument makes a student better able to learn to program? Alternatively, perhaps musical ability indicates the presence of creative skills such as those required for software design? Of course, the explanation might have more to do with the socio-economic status of the student. Further work will be necessary to investigate which (if any) of these explanations is correct.

While these findings are interesting, it is evident from the APTS scores and academic results (Figure 7) that the sample of students is somewhat homogenized. Most of the marks lie in the upper right quadrant, above the 50% score for both the APTS and the academic results.[4] Presumably this is because those students who would have

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[4] There were 68 APTS questions, so a score of 34 corresponds to 50% in Figure 7.

appeared in the lower-left quadrant (low APTS, low academic) did not reach the second year of the course. The majority of 'churn', where students withdraw or are terminated, occurs in first year; by second year most of the weak students are gone. Homogenization of the sample may explain the lack of statistically significant demographic dependencies compared with Study 2.

The APTS did not show bias against non-native English speakers. However, analysis of the demographic data suggests that academic performance was significantly lower for overseas students (based on Country of Birth), which suggests that these students are disadvantaged as in Study 2. Furthermore, although the APTS did not appear to be linguistically biased, this could be due to the homogeneity of the sample.

Finally, the results from the Quantitative and Abstract reasoning tests were not significantly correlated. This suggests that using all four APTS components in full would be more informative, and hence useful in recruiting new students.

6. Conclusions And Further Work

The results of this work suggest that the APTS could be used as an aid to identifying students who are likely to succeed in computing degree courses. APTS scores could be combined with high-school academic results and perhaps an interview to improve the student recruitment process for all concerned.

To confirm the results of these exploratory studies, it will be necessary to obtain a large sample of first-year students from the Computer Science, Information Technology, and Software Engineering courses early in the academic year. Given the poor response from the first-year students of 2003, it is unlikely that simply asking for volunteers will be a successful strategy in the future.

An alternative strategy would be to provide an incentive, but the financial cost would be considerable, and there is no guarantee that the resulting sample would not be homogenised in some way. Another strategy would be to make participation compulsory. This would require very careful ethical consideration, especially given that many of the students would be minors.[5] The results of this exploratory work might help to justify such an approach.

Given a large sample of first-year students it would be interesting and worthwhile to monitor long-term academic progress, and to include students who withdraw or are terminated, as well as those who eventually graduate. The study could be conducted over a number of years, with several different first-year intakes, to ensure that the results are repeatable. The findings of such a study could be used for student recruitment, improving student retention and the number and quality of graduates from computing degrees.

[5] In Western Australia students can enter University at the beginning of the year in which they reach eighteen years of age.

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References

[1] Kline, P. Handbook of Psychological Testing.

[2] Palormo, JM; Fisher, BM: 1964. *Computer Programmer Aptitude Battery (CPAB)*. Science Research Associates, Inc.

[3] http://www.cs.curtin.edu.au

[4] Konvalina, J; Wileman, SA; Stephens, LJ: 1983. Math proficiency: a key to success for computer science students. *Communications of the ACM*, **26** (5), 377–382.

[5] Campbell, PF; McCabe, GP: 1984. Predicting the success of freshmen in a computer science major. *Communications of the ACM*, **27** (11), 1108–1113.

[6] Butcher, DF; Muth, WA: 1985. Predicting performance in an introductory computer science course. *Communications of the ACM*, **28** (3), 263–268.

[7] Byrne, P; Lyons, G: 2001. The effect of student attributes on success in programming. *Sixth annual conference on Innovation and technology in computer science education*, 49–52.

[8] Wilson, BC; Shrock, S: 2001. Contributing to success in an introductory computer science course: a study of twelve factors. *Proceedings of the 32nd SIGCSE technical symposium on Computer Science Education*, 184–188.

[9] Morgan, G; Stephanou, A; Simpson, B: 2000. *Aptitude Profile Test Series Manual*. Australian Council for Educational Research, Hawthorn, Victoria. http://www.acer.edu.au

[10] Ong, M: 2003. Psychometric assessment of potential computing students. Honours Dissertation. Department of Computing, Curtin University of Technology, Perth, Western Australia.