Success predictors for computing students: the next step

Karen Phillips
Bay of Plenty Polytechnic
Private Bag 12001
Tauranga
New Zealand
karen.phillips@boppoly.ac.nz

Ray Scott
Bay of Plenty Polytechnic
Private Bag 12001
Tauranga
New Zealand
ray.scott@boppoly.ac.nz

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Abstract

This paper follows on from the retrospective study presented at the 1st annual conference of Computing and Information Technology Research and Education New Zealand (CITRENZ2010) by the current author into the identification of success predictors for Level 5 IT students in a New Zealand Polytechnic. In 2010, a new cohort of Level 5 IT students was studied from enrolment until the end of 2010. Measures included an initial questionnaire on previous experience, current attitudes and future intentions, a measure of literacy and numeracy and a test of Multiple Intelligences. These data, together with information from the Polytechnic's Management Information System (SMIS) about gender, age, ethnicity and date of enrolment was correlated with results in each individual course and with overall results at the end of semester 1 and 2. Results indicate a difference in predictive factors for programming than for other IT courses, significant relationships between literacy and numeracy scores and multiple intelligence measures with some courses, but not others. The strongest positive relationship was between confidence on day one and results in semester one and semester two.

Keywords

Student selection, success factors, computing and IT education, tertiary education, New Zealand

Introduction

In 2010 the author presented a paper to the 1st CITRENZ Conference in Dunedin summarizing the results of a retrospective study into success predictors for Level 5 (first year degree) students who had studied the Diploma in Information and Communications Technology between 2004 and 2009 at a Polytechnic in New Zealand. This research had been undertaken as a response to questions from local industry representatives wanting to know how students were selected and why the Polytechnic did not wait for all applications to be submitted and then pick “the best”. The only data available was that recorded in the Student Management Information System and this study was therefore restricted to factors such as gender, age, ethnicity, part- or full-time status, previous tertiary programmes completed and length of time between enrolment and start date. Measures of success examined included graduate status, total number of courses passed, total number of merit grades gained, percentage of courses passed and number of semesters taken to reach graduation. The two most important determinants of success were found to be age at start, with older students performing better and number of days between enrolment and start date, with the greater time gap leading to higher success outcomes (Phillips, 2010).

Although these results did not contradict previous research by Goold and Rimmer (2000) and Byrne and Lyons (2001), many of the potential independent variables were not available without access to the participants. Goold and Rimmer(2000) and Davidson, Savenye and Orr(1992) reported differences in success predictors for programming courses than for information technology courses, with programming success being more closely linked to abstract learning and success in Information Technology to concrete learning. Byrne and Lyons (2001) had found a weak link between programming success and previous maths ability and a stronger link with previous success in science.

However, factors other than these have been shown to be contenders as predictors of success for students in computing. Rountree, Rountree and Robins (2004) collected survey data from almost 500 students enrolled in a first year degree paper in Computer Science at a New Zealand University and compared these data with results in that paper. The paper examined was taken by first year undergraduates in the Computer and Information Science department but was also an option for students taking other majors. They asked participants about whether or not they intended to continue studying computer science, about previous maths studied in college or at University, expected workload from that paper, previous knowledge of a programming language, expected difficulty and expected result. The strongest single indicator of success was expecting to get an A grade from the course. They concluded that students were good at judging their own abilities and potential. A different explanation might also be possible. In Rosenthal and Jacobson’s (1966) study of self-fulfilling prophecy, it was the teacher’s expectation of student achievement that had an impact on results. In a public lecture on 10 July 2006, Benjamin Zander described the effect of telling all students that they would get an A grade so long as they wrote a letter to him at the beginning (but dated at the end) of the course telling him what they had done to deserve this. Zander reports significant improvements in level of achievement once the anxiety of what grade they might attain was lifted and the possibility of achieving great things was believed by the students.

Wilson and Shrock (2001) also focussed their study of factors contributing to success in an introductory computer science course on a mixture of possible predictors. These included "traditional factors" such as previous computing experience (programming and non-programming), maths background, and also psychological characteristics such as attribution for success/failure, domain specific self-efficacy, work-style preference and comfort level on the course. Comfort level and maths background were found to have a positive relationship with success but attributing success to luck had a negative effect. Comfort level was a measure derived from answers to questions around comfort when asking and answering questions in and out of class, anxiety level while working on a computer, perceived difficulty understanding the course and completing the assignments. In a second level analysis, the importance of having a competitive/individual work style preference (positive) and attribution of success/failure to task difficulty (negative) also emerged as predictors of success at mid-term, but not at the end of the course. This suggests that by the second half of a course, different predictors might come into play, including knowledge of mid term performance and the experience of the first half of the course.

In 2010, the Level 5 Diploma being offered changed to one which also counted as the first year of a University degree rather than a Polytechnic degree. It is possible therefore that the cohort of students might differ from that studied by Phillips (2010) (relating to students during the 2005 – 2009 period). However, if the previous results were to be of real value, the extent to which they would also apply to the new cohort was important. Equally, the chance to interact with participants and collect additional data was essential.

Methodology

On the first day of the new Diploma, students were given an explanation of the research to be conducted and asked to sign a letter to agree (or not) to participate. All participants were then given a questionnaire to complete which collected data about their previous study in computing and in general, current living arrangements, hours of part-time work, confidence level, level of motivation and about career aspirations. Demographic data was also collected to include, age, gender, ethnicity and first language.

Data was then stored electronically against an assigned research ID. Further data was added from SMIS such as date of enrolment. Participants who were already part-way through the new diploma (because of cross-credit from the previous qualification) were excluded from the study.

In the second and third weeks of the programme, students were asked to complete the New Zealand Adult Literacy and Numeracy Tests, specifically the adaptive tests in reading comprehension and numerical ability. These tests are taken online and start with questions of average difficulty. As participants get questions correct, so the level slowly increases and vice versa. Results place the student on a 6 point scale from 1 is very low to 6 is very high. It also provides a score between 0 and 1000.

The final measurement tool was the online Multiple Intelligences VAK (Visual-Auditory-Kinesthetic) test (Chapman and Chislett, 2005) based on the work of Howard Gardner (1993). This is a questionnaire style diagnostic which measures intelligences against 7 intelligences; linguistic, logical-mathematical, musical, bodily-kinesthetic, spatial-visual, interpersonal and intrapersonal. These data, together with the numeracy and literacy data were added to the student records.

At the end of each semester, students' marks for each of the four courses they had studied were recorded. Student who withdrew from the course in the first two weeks were excluded from the study. In total there were 59 participants of whom 8 were international students, and 7 were female.

Measures of success examined included mean percentage for each semester and annual mean percentage together with percentage of papers passed. In addition to analyzing the data collected as part of this research, results in semester 1 were also compared with results in semester 2 to see if these could be used as potential success predictors for semester 2.

Results

Of the 59 students who participated only 11.9% were female. It can be seen from Figure 1 below that almost 60% of participants identified as NZ European, with fairly small numbers in all the other groups. 81% of participants were under 25.

Ethnicity	%
NZ European	62.7
NZ Māori	10.2
Indian	13.6
Other	13.6

Figure 1: Ethnicity

Age group at start	%
Under 19	33.9
19 - 24.99	47.4
25 – 34.99	11.9
35 and over	6.8

Figure 2: Age group

No statistically significant results were found relating to gender, ethnicity or age-group, although there are some patterns in the mean percentages scored in semester 1, semester 2 and for the whole year.

Gender	*Mean Sem 1 %*	*Mean Sem 2 %*	*Annual Mean %*
Male	65.85	53.25	59.49
Female	67.69	59.96	63.29

Figure 3: Results by Gender

Ethnicity	*Mean Sem 1 %*	*Mean Sem 2 %*	*Annual Mean %*
NZ European	69.11	52.87	61.61
NZ Maori	59.21	59.45	54.67
Indian[1]	67.94	61.49	64.94
Other	55.38	47.96	51.15

Figure 4: Results by Ethnicity

Age-Group (age at start)	*Mean Sem 1 %*	*Mean Sem 2 %*	*Annual Mean %*
Under 19	64.43	48.35	56.60
19 – under 25	67.27	58.56	61.80
25 – under 35	66.21	47.63	59.90
35 and over	65.81	62.17	63.68

Figure 5: Results by Age Group

[1] Indian was included as a specific group because of the large numbers of students from the same country.

To summarise the above, female students did slightly better than the males. NZ Maori students did not do quite so well as other NZ European or Indian students, but it should be noted that the standard deviations for NZ Maori were higher too, at around 29 annually in comparison with 19 for NZ Europeans. The Indian students did much better than might be expected and in semester 2 had the highest mean mark. Participants in the "other" group all had English as a second language but did not have the advantage of having other speakers of their first language on the Diploma. The annual mean score for Indian students also had the lowest standard deviation, just 4.7.

There was no correlation between the number of days between enrolment and programme start and success by any measure.

The MI_VAK Test yielded some interesting results. Participants rank all statements in the questionnaire from 1 = Mostly disagree, through 2 = Slightly disagree, 3 = Slightly agree to 4 = Mostly agree. To calculate results, statements are categorised according to the type of intelligence to which it relates and totals for each of the seven intelligence types are given. It was noted that some students tended to give mostly 1's and 4's whereas others used mainly 2's and 3's. The relative ranking of each intelligence type within the participant's scores was therefore calculated and used as well as actual scores to determine relationships with measures of success. Although there were no significant correlations with overall scores in semester 1, 2 or annual, statistically significant correlations at the 5% level (two-tailed) were found between some intelligences and some individual courses.

MI-VAK relationships with specific courses	*Logical-mathematical p*	*Spatial Visual p*	*Linguistic p*	*Rank linguistic p*	*Rank spatial-visual p*
Introductory programming	.024				
IT Infrastructure		.031			.034
Behavioural Science			-.047	-.01	
Software Packages					.041

Figure 6: Significant correlations between specific intelligences and courses (2 tailed)

Correlations between scores on the adaptive version of the online Adult Literacy and Numeracy Assessment Test and measures of success were again varied. The numeracy test had a correlation of .288 p = .068 with mean scores in semester 1 and a significant positive correlation of .378 p = .014 with IT Infrastructure. Results of the reading assessment showed no significant correlation with any measure of success. In order to consider the validity of the two measures, correlations between high linguistic intelligence and scores on the reading assessment and between high logical-numerical intelligence and scores on the numeracy assessment were calculated. There was a correlation of p = .027 between linguistic intelligence and reading score but no significant relationship between logical-mathematical intelligence and numeracy.

The initial questionnaire answered at orientation asked several questions to which the majority of students made the same response and which therefore did not allow for any analysis. Results for the question about the type of living arrangements while studying yielded the following results.

Living arrangements	%
With family	67.8
With friends	11.9
Alone	3.4
Other	3.4
System missing	13.6

Figure 7: Living arrangements while studying

All but one of the participants was enrolled as a full-time student.

In answer to the question "How confident are you that you are going to pass?" results were;

Confidence	%
100%	27.1
Fairly confident	44.1
50:50	13.6
Unlikely to pass	6.8
System missing	8.5

Figure 8: How confident are you that you will pass?

There was positive correlation between confidence and all measures of success, the more confident, the better the marks.

Correlation between confidence and results	*P(2-tailed)*
Mean semester 1	.036
Mean semester 2	.076
Annual mean	.037

Figure 9: Correlation between confidence and results

There was no relationship at all between self-rated current IT knowledge and success.

Participants were asked to rate their motivation to succeed on a 10 point scale where 1 was not at all through to 10 = highly motivated. This yielded a significant positive correlation with results for semester 2 (p = .036) but not for semester 1.

A strong positive relationship existed between the highest previous qualification (in any subject) and success measures.

Correlation with highest qualification	*P (1 tailed)*
Mean semester 1	.057
Mean semester 2	.005
Annual mean	.017
% courses passed sem 1	.015
% courses passed sem 2	.011
Annual % courses passed	.011

Figure 10: Correlation between highest previous qualification and results

However, in relation to their highest previous qualification in an IT-related subject, there was no correlation at all with success.

Participants in this study were enrolled on a one year Level 5 Diploma which they could also choose to count as the first year of a three year degree. Another option is to stay for two years and complete both the Level 5 and Level 6 Diplomas or count Level 6 Diploma as the second year of their degree. When asked about their intentions at the outset, results were as follows;

Study intentions	%
Level 6 then degree	55.9
Level 6 then work	1.7

Study intentions	*%*
Work	11.9
Other	3.4
No idea	3.4
System missing	23.7

Figure 11: Study intentions after current diploma

Career Goal	*%*
Web developer	11.9
Network engineer	5.1
Technician	3.4
Help Desk	1.7
Systems analyst	1.7
Not sure	39.0
Other	15.3
System missing	22.0

Figure 12: Career goal

Neither study intention nor career goal had any relationship with success. The number of hours of paid work that they intended to do during their study had no relationship with success.

Finally, results of semester 1 were examined to see if they could successfully predict results in semester 2. In semester 1 all students take the same four courses. In semester 2, students in the degree pathway also take the same four courses but those not intending to continue on to the degree can choose four from 8 courses. Numbers in the non-degree courses were small (they are joined by students from other programmes) and so analysis has focussed only on the degree pathway. All four first semester courses showed a positive correlation with the mean score in semester 2. However, the strongest predictor was the mark in IT Infrastructure.

Semester 1 as predictor of semester 2	*Mean sem 2*
Introductory Programming	.486
Professional skills	.385
IT Infrastructure	.537
Software packages	.358

Figure 12: Pearson Product Moment Correlation coefficients between semester 1 course results and mean score in semester 2

Conclusion

These results reveal some unexpected patterns in that a number of measures that could reasonably be expected to relate to each other did not. For example, it would seem reasonable to assume that a high score on the numeracy assessment would have a positive correlation with success in Statistics - none was found. Equally, a high score on the reading assessment could be expected to correlate with Professional Skills and also with Behavioural Science – the two courses in which essay/long report writing is most important. Again, none was found. There was a weak correlation between scores on the numeracy test and mean score in semester one, perhaps indicating that better numeracy skills is more likely to lead to better outcomes in the initial courses. One possible explanation for these results is that the reading and numeracy tests are not good measures of the skills students need to succeed at this level in a Computing degree. Scores on the numeracy assessment did correlate with percentage in IT Infrastructure suggesting the skill being assessed might be more akin to this curriculum area than to mathematics. However, further analysis of results for a larger group of students on similar courses would be necessary before any conclusion could reasonably be drawn.

Similarly, there was no correlation between literary intelligence and professional skills and a negative correlation between literary intelligence and Behavioural Science. However, there was a significant positive correlation between linguistic intelligence and reading score, suggesting that there is some commonality on what is being measured. This is hard to explain, although the main assessments for Behavioural Science both include a large section of multiple-choice questions and another section requiring only short answers thus reducing the importance of literary skills in success.

The correlation between logical-mathematical intelligence and programming success supports the findings of Byrnes and Lyons (2001). The correlation between It Infrastructure and a different intelligence type (spatial-visual) also supports the difference in predictors for programming and Information Technology courses found by Goold and Rimmer(2000) and Davidson, Savenye and Orr(1992). This information, together with scores in early courses, might help guide a student into the right pathway for the future years of their degree. The correlation between spatial-visual intelligence and software packages might possibly reflect the inclusion of PowerPoint in this course.

The lack of correlation between number of days between enrolment and start of programme and success is contradictory to the results reported by Phillips (2010). One possible explanation for this is the much closer monitoring of student performance and attendance during the first two weeks of the programme with a view to moving students onto more appropriate programmes if necessary or suggesting that they transfer to a later semester when they might have a greater chance of success. Almost all of the students who chose to leave the programme in the first two weeks were late enrollers and, had they stayed, might have changed the results of this factor in this study. A higher proportion of these early withdrawals was made by Maori students, this may also have affected results.

From the questionnaire, the two strongest predictors of overall success that emerged were confidence at the beginning that they would pass and having a high level of previous qualification (but not necessarily in IT). The importance of confidence level supports the findings of Rountree et al (2004) who found that the strongest single indicator of success is the expectation that they would succeed. This may be based on knowledge of their own previous results as Rountree et al suggest, but there are other explanations. As long ago as 1966, Rosenthal and Jacobson (1966) demonstrated that the teacher's expectation of a student's likely results was a strong indicator of the final grade. Further studies on the "Pygmalion Factor" (as this phenomenon became known) have yielded similar results (Rosenthal & Rubin, 1978). Benjamin's Zander's work with the students at the New England Conservatory has shown that instilling a sense of belief in one's capacity to succeed and removing the fear of failure has a significant positive impact on performance. If a student is confident that s/he will succeed, their fear of failure is removed (or weakened) and they are more open to the possibility of success. This then becomes a self-fulfilling prophecy..

The correlation between highest previous qualification and result is to be expected in that previous success has very likely given the student exposure to good study habits and a belief in their own ability to succeed. The fact that there was no correlation with previous highest IT qualification suggests that this experience is transferable between domains.

The significant positive correlation found between motivation at start and results in semester 2, but not semester 1 is interesting. Perhaps it is this motivation that keeps students persevering when they get into the second half of the year?

Results in semester 1 are a good indicator of likely success in semester 2, even though, in the specific Diploma being studied, the courses are quite different as they have to include a Statistics course, two courses in science that are not computer science and only one, "traditional" IT subject – Multimedia. Success in IT Infrastructure is the strongest of all these predictors.

The fact that some potential indicators correlated with semester 2 results but not semester 1 and vice versa supports Wilson and Shrock's (2001) findings that by the second semester, other factors, including the experience of the first semester and knowledge of these results came into play as predictors of success. In this study motivation at outset related to only semester 2 results, the numeracy results correlated with semester 1 results, but not semester 2.

Finally, one additional pattern was found. Regardless of the year in which they were born, there was a strong positive correlation between birth month and success, with students born later in the year getting high marks in both semesters (p = .01, 2-tailed). This analysis was carried only because the author was reading Malcolm Gladwell's "Outliers" (2009) at the time these data were being analysed. In this book, Gladwell explains why most American professional ice-hockey players are born in the first few months of the year in terms of relative age within the school year, correlation with physical size at age seven when initial selection takes place and subsequent "hot-housing". This and other books such as "Freakonomics" (Levitt and Dubner, 2005) have shown how an apparently "freaky" relationship has a rational explanation. At this point in time, no clear rational explanation has been idenitified for this particular finding.

This study is currently being repeated in two other Polytechnics in New Zealand on a comparable cohort. It will be fascinating to see how similar the results are. Once all this data is pooled, those factors that are common should be given serious investigation to see how they can be used to help students make good choices about appropriateness of programmes and pathways. If confidence proves to be one of these factors, then looking at ways that tutors can help instil this confidence in their students will be very important.

References

Byrne, P., & Lyons, G. (2001, June 25-27). *The effect of student attributes on success in programming.* Paper presented at the 6th Annual Conference on Innovation and Technology in Computer Science Education, Canterbury, United Kingdom.

Chislett, V., & Chapman, A. (2005). VAK Learning Styles Self-Assessment Questionnaire.

Retrieved 20 March, 2011, from www.businessballs.com.

Davidson, G. V., Savenye, W. C., & Orr, K. B. (1992). How do learning styles relate to performance in a computer application course? *Journal of Research on Computing in Education, 24*(3), 349-358.

Ferguson, E., James, D., & Madeley, L. (2002). Factors associated with success in medical school: systematic review of the literature. *British Medical Journal, 324*, 952-957.

Gardner, H. (1993). *Frames of mind: The theory of multiple intelligences*. London: Fontana Press.

Gladwell, M. (2009). *Outliers : the story of success*. London: Penguin.

Goold, A., & Rimmer, R. (2000). Factors affecting performance in first-year computing. *SIGCSE Bull., 32*(2), 39-43.

Goold, A., & Rimmer, R. (2000). Factors affecting performance in first-year computing. *ACM SIGCSE Bulletin, 32*(2), 39-43.

Levitt, S. D., & Dubner, S. J. (2005). *Freakonomics: A rogue economist explores the hidden side of everything*. London: Allen Lane.

Phillips, K. (2010, July 6-9). *Selecting best students for IT programmes: What determines best?* Paper presented at the 1st annual conference of Computing and Information Technology Research and Education New Zealand 2010, Dunedin.

Rosenthal, R., & Jacobson, L. (1966). Teachers' expectancies: determinants of pupils' IQ gains. *Psychological Reports, 19*(1), 115-118.

Rountree, N., Rountree, J., Robins, A., & Hannah, R. (2004). Interacting factors that predict success and failure in a CS1 course. *SIGSCE Bulletin, 36*(4), 101-104.

Wilson, B. C., & Shrock, S. (2001). *Contributing to success in an introductory computer science course: a study of twelve factors.* Paper presented at the Thirty-second SIGCSE technical symposium on Computer Science Education, Charlotte, North Carolina, United States.

Zander, B. (2006). Everyone's an A student. Retrieved March 21, 2011, from http://www.teachers.tv/videos/benjamin-zander