Studying computer programming externally: Who succeeds?

T.J. McGill, S.E.Volet and V.J. Hobbs

Abstract

Learning computer programming is difficult for many students. Distance education students in particular often have problems as the difficulty of the course content is compounded by the problems of isolation from other students and their tutor. This paper reports an investigation of distance education student performance in an introductory computer programming course. The aim of the study was to develop a better understanding of the factors associated with academic success, withdrawal or failure and to attempt to identify students at risk of non-completion. Some implications for teaching computer programming externally are discussed.

Introduction

The nature of course content has been shown to have an important relationship to other factors impacting on course completion for distance education students (Bernard & Amundsen 1989). In her study of barriers to persistence of distance education students, Garland (1993) stressed the need to consider the nature of the course content. Learning computer programming is difficult for many students (Canas, Bajo & Gonzalvo 1994). Writing a computer program requires a broad range of knowledge and skills ranging from highly specific knowledge of the programming language and skill with the programming environment through more general problem solving strategies and application domain knowledge (Brooks 1990). Students often can become too concerned with learning the syntax (i.e. grammar) of a programming language and consequently may not acquire the more general, transferable conceptual knowledge. Distance education students in particular often have problems as the difficulty of the course content is compounded by the problems of isolation from other students and their tutor. This paper describes an investigation of distance

education student performance in an introductory computer programming course and discusses some of the implications.

Retention rates

A consequence of the problems faced by distance education students is that these students are more likely to withdraw from individual courses and programmes of study than are internal students (Glatter & Weddell 1971; Kaeley1993). Even the Open University, which has the reputation of providing good quality study packages and high levels of student support, has reported that little more than 50 per cent of an undergraduate intake eventually graduate (McIntosh, Woodley & Morrison 1980).

Given the nature of learning computer programming, there is reason to believe that students studying externally face an even higher risk of withdrawal than those enrolled in other disciplines. In their investigation of student dropout from distance education courses, Woodley and Parlett (1983) concluded that wastage rates (dropout and failure) were above average for mathematics and technology courses. Similarly, an analysis of the retention rates of students in the introductory course in computer programming offered at Murdoch University suggested that distance education students were twice as likely to withdraw as internal students enrolled in the same course. Few studies, however, have examined the extent to which enrolment in an external course, and completion in that course, are confounded by or interact with other variables.

Roberts (1984) found that the time that a distance education student is at greatest risk of dropping out is during their first term, semester or year of study. According to Coldeway (1986), it appears that students who complete one or more courses have a much higher probability of going on to complete

their programme of study. There is thus a particular need to identify introductory computing students who are at risk of withdrawal and to provide them with appropriate support at the beginning of their study.

Demographic factors

Some research on the relationship of demographic factors to academic achievement indicates that in the case of distance education students, variables such as age, sex, location and previous academic experience are generally unrelated to course completion and academic performance (e.g. Coldeway 1986; Kember, Lai, Siaw & Yuen 1992). However, Kaeley (1993) in a study of mathematics achievement of distance education students, found that background variables such as socioeconomic status and previous academic achievement may be more important for distance education students than for internal students. Similarly, Woodley and Parlett (1983) found that in general men were more likely to drop out than women and that very young and very old students were more likely to drop out. They also found that previous educational background had an impact on dropout such that the lower a person's previous educational qualifications the more likely they were to drop out. Through their examination of demographic characteristics they showed that there was some relationship between demographic characteristics and dropout in distance education courses. Overall, these findings suggest that the difficulty of studying externally is magnified for students with some background handicaps or when the nature of the course is particularly demanding, as seems to be the case with introductory computer programming.

Research on factors that potentially influence the learning of students enrolled in on campus introductory computer programming courses has provided evidence that while gender and age do not appear to influence achievement (Dalbey & Linn 1985; Volet & Lund 1994; Volet & Styles 1992),

background in computing is among the best predictors of performance (Kersteen et al. 1988; Volet & Styles 1992). The relationship of achievement in introductory computer programming courses to general ability (Clarke & Chambers 1989; Dalbey & Linn 1985) and programme of study - i.e. whether they are majoring in computing or in other programmes (Volet & Lund 1994) - also has been highlighted. The relative role of these factors in studying computer programming in distance education is not well documented and needs to be investigated.

Contact with tutors and other students

A survey conducted at Murdoch University (Aveling, Smith & Wilson 1992) documented the typical problems experienced by distance education students. The most common problems cited were lack of contact with tutors and isolation from other students. Davies and Preece (1990) suggest that lack of fellow students or tutors to provide help in case of need is one of the most important differences between face to face instruction and distance learning. It has been proposed as one of the most important reasons students give for withdrawing (Harrington 1979). The problem of lack of contact is compounded for distance education students studying computing because of the dependence on software and hardware. Just explaining the nature of problems with software and hardware over the telephone is beyond many students in introductory courses. Jennings and Atkinson (1982) claim that course design for computer programming courses is more difficult than for any other discipline because of this dependence on equipment. Davies and Preece (1990) attempted to compensate for lack of contact in an Open University introductory programming course by supplementing tutor contact with a help-line and a series of 16 television shows. Similarly, McGill and Hobbs (1996) provided students with a supplementary video and workbook in an attempt to address some of the problems distance education students face due to lack of contact. MacCallum's (1995) attempt to encourage interaction among external students, using educational technology, was well received by students.

Motivational factors

The importance of general motivational dispositions on academic achievement is well established in the educational literature. Recent research (Boekaerts 1994; Volet 1997), however, has revealed the greater predictive power of situation-specific cognitive and affective variables in explaining performance in comparison to trait-like motivational variables. The significance of process variables on achievement in distance education - in addition to demographic factors, institutional characteristics and stable individual characteristics - was acknowledged in Tinto's (1975) early model of dropout from higher education and supported by Sweet's (1986) application of Tinto's model in a distance education programme. Kember et al's (1992) more recent model of student progress in distance education also acknowledges the importance of factors other than academic or demographic. Their conceptual framework incorporates the degree to which distance education students are able to integrate their studies with their home life, social activities and work commitments. The significance of external students' personal lives and work constraints on dropout is a recurrent theme in the distance education literature (Peters 1992). Motivational and emotional variables are emphasised throughout the empirical distance education literature. To cite just a few studies, Coldeway (1986) claimed that motivational factors and the actual behaviour of learners after enrolment were more important than demographic factors, and Bernt and Bugbee (1993) suggested that while ability is a more critical factor in achievement among younger students, attitudinal, motivational, and personality factors may contribute more to differences in achievement among the older students who form the majority of distance education students.

A comparison of distance education and internal students by Wong (1992) found that distance education students reported a greater interest in the courses they are studying (for their own sakes) and lower extrinsic motivation (interest for the qualifications they offer). They also displayed higher intrinsic motivation, higher incidence of inter-relating ideas and a greater use of deep approaches to

learning. Finally, their fear of failure was lower than that of internal students (Wong 1992). Wong suggests that the differences could be due to the different learning environments: full time study by face to face instruction versus teleconference study. However, in a comparative study of internal and distance education students taking the same course, Harper and Kember (1986) found that the approaches to study of distance education students were not qualitatively different from those of students studying face to face. A better understanding of the significance of students' initial cognitive, motivational and volitional appraisals of their study is needed to be able to identify the students at risk of dropping out from their distance education courses.

Research suggests that finding the time to complete course requirements can be a major problem for distance education students. Gibson and Graff (1992) found a significant difference in finding enough time to study between students who successfully completed a distance education course and those who did not. This problem is potentially greater for programming courses because of the large investment in time that is typically required for completing the hands-on component of the course (Volet & Lund 1994). Being aware upfront of the time commitment required and being able to accommodate it may be important to success in studying computer programming through distance learning.

In conclusion, this brief review of prior research on the determining factors in successful distance education and on predictors of achievement in introductory computer programming suggests that success in studying computer programming externally is affected by a whole range of personal factors - demographic and psychological – as well as contextual factors. Woodley and Parlett's (1983) multivariate model to identify 'high risk' students acknowledges the complexity of personal and motivational factors affecting study at a distance. They claim that at-risk students should be singled out for special attention before and during their studies in order to reduce the high wastage rates in distance education. The crucial issue is to be able to identify early enough who are the students at risk.

This can only be achieved through developing a better understanding of the factors associated with academic success, withdrawal or failure.

Research questions

The present study aimed at providing insight into the specific factors associated with success in studying computer programming externally. Coldeway (1986) provides a number of examples of definitions of success which have been proposed or used in previous studies. These include course marks, completion rate, student satisfaction and follow-up measures such as getting jobs. In the present study, course completion was used as the measure of success because the major problem in introductory programming courses tends to be dropout rather than failure. Students who successfully completed the course were labelled as Completers and those who either withdrew or failed were combined to form a Noncompleters group. Collapsing students who failed with those who withdrew into a single category was also used by Sweet (1986) and by Bernard and Amundsen (1989). This categorisation was considered as appropriate in the present study because of the high proportion of 'unofficial dropouts' in previous years. Unofficial dropouts consist of students, typically in their first year at university, who are struggling with their study and do not withdraw in time to avoid a Fail grade on their academic record. Empirical support for this categorisation was provided by an exploratory discriminant analysis which was unable to differentiate successfully between those who failed and those who withdrew.

Two research questions were addressed in this study:

1. How do students who successfully completed a distance education introductory programming course differ from those who did not complete it, in terms of personal characteristics, entering expectations, and initial perceptions of the difficulties involved in completing the course?

Based on a review of the literature on student dropout from distance education and on student learning in introductory programming the following hypotheses were generated:

i. Completion of the distance education introductory programming course is not related to students' age or gender.

ii. Students with prior experience of studying externally are more likely to complete the course than those for whom the course is their first experience of distance education.

iii. Students with programming experience and those majoring in computer science are more likely to complete the course than those without experience or who are enrolled in another programme of study.

iv. Students with high university entrance scores are more likely to complete the course than students with low scores.

v. Students who have relatively realistic estimates of the time required to study in a distance education introductory programming course at the beginning of the semester are more likely to complete that course than those who tend to underestimate that time.

vi. Students who are more confident in their ability to complete the course, and those who expect that they will attain a higher level of competence in programming, are more likely to complete it successfully in comparison to those less confident.

vii. Students who perceive the course as more relevant to their programme of study, and those who are more interested in the course, are more likely to complete it successfully in comparison to those who do not perceive the course as relevant or those who are less interested.

Students' perceptions of the importance of various factors in contributing to their potential success in the course are of interest as well. However, no specific hypotheses were generated regarding students' rating of importance of factors in contributing to their success, as this part of the study was exploratory in nature. The list of factors was inspired by psychological research on the significance of causal attributions of success and failure in academic study (Werner, 1979). It included two internal factors: own ability (uncontrollable) and hard work (controllable); and four external factors: good

materials and difficulty of the course (uncontrollable physical factors) and help from tutor and from friends/family (relatively uncontrollable social factors).

2. Can students' completion or non-completion of a distance education introductory programming course be predicted on the basis of students' personal characteristics, entering expectations and initial perceptions of the difficulties involved in completing the course?

Method

The study was conducted with three consecutive cohorts of university students enrolled in a distance education (external) mode of an introductory computer science course. Three cohorts were used in order to increase the number of students surveyed. The content and organisation of the course was the same for the three cohorts and consistent with the on campus offering. The course taught Pascal as a first programming language. Students taking the course were supplied with a print based study guide and allocated a tutor who could be contacted by telephone to help solve problems the student might have. This approach to teaching computer programming externally is comparable with approaches used in other Australian universities (Jones, 1996).

Each student was sent a questionnaire, with an accompanying letter explaining the purpose of the study, in the first week of the semester. The questionnaire contained two sections. The first section requested personal details such as the student's age, sex, programme of study, whether it was their first experience of external study, and the extent of their previous experience with computing. The second section requested information about the students' initial expectations and perceptions of the course and their learning in it. The questions included how many hours they expected to spend studying in the course, how confident they were of their ability to complete the course, and how difficult they thought it would be to study the course externally. They were also asked to rate the

importance of a number of factors that might contribute to their success and to rate a number of factors that might affect their ability to complete the course successfully. These factors were rated on a Likert-type scale where 1 was labelled Not Important and 5 was labelled Very Important. Students who failed to return the questionnaire after four weeks were sent a reminder, although by then it was too late to obtain their initial perceptions. Students' results in the course were obtained from university records.

Profile of respondents

A total of 129 responses to the questionnaire were received giving an overall response rate of 78%. There were missing values, however, on a number of variables. First, data on initial perceptions was unavailable for the 22 students who failed to return the questionnaire within 4 weeks. Second, university entrance scores were not available for 48 students who had entered the university via an alternative entrance test, or who had completed their schooling prior to these scores being provided to universities.

The characteristics of the respondents are summarised in table 1. The majority of students were over 30 years of age or over and male. The course under consideration was the first external course for approximately half of the students and approximately two thirds of the students were computer science majors for whom the course was mandatory. Although almost all of the students had some experience with computers only about one third had any previous computer programming experience.

TABLE 1

Profile of sample

		N	*(%)*
Age	*below 3D*	43	*(33.3%)*
	30orover	86	*(66.7%)*
Gender	*Male*	88	*(68.2%)*
	Female	41	*(31.8%)*
Programme of study	*Computer Science*	87	*(67.4%)*
	Other	42	*(32.6%)*
Programming experience	*Some*	46	*(36.5%)*
	None	80	*(63.5%)*
First external course	*Yes*	67	*(52.3%)*
	No	61	*(47.7%)*

Results

This section is structured around the two main research questions and the eight hypotheses, generated as part of the first question.

Differences between course Completers and Noncompleters (first research question)

Personal characteristics. A series of χ^2-tests were conducted to determine whether demographic factors such as age, gender [hypothesis (i)], prior experience of external study [hypothesis (ii)], programming experience, programme of study [hypothesis (iii)], as well as general ability represented by students' university entrance score [hypothesis (iv)], were related to course completion. Table 2 and table 3 show the breakdown of course Completers and Noncompleters by each variable.

TABLE 2

Breakdown of course Completers and Noncompleters by several variables

	N	Number of completers *(%)*	Significance
Age			
below30	43	23*(33.3%)*	n.s.
30 or over	86	58*(66.7%)*	
Gender			
Male	88	*59 (67.0%)*	n.s.
Female	41	22*(53.7%)*	
First external course			
Yes	67	41 *(61.2%)*	n.s.
No	61	39 *(63.9%)*	
Programme of study			
Computer Science	87	56*(64.4%)*	n.s.
Other	42	25 *(59.5%)*	
Programming experience			
Some	46	34*(73.9%)*	p<.05
None	80	*45 (56.3%)*	

The first hypothesis, that completion is not related to age or gender, was supported as there were no significant differences in *age* or *gender* between Completers and Noncompleters.

The second hypothesis was not supported as there were no significant differences between Completers and Noncompleters in whether this course was a student's first *experience of external study* or not.

The third hypothesis was only partially supported with Completers differing significantly from Noncompleters in terms of *computer programming experience* (χ 2(1) 3.89, p<.05) but not in terms of whether or not they were *majoring in computer science.*

The fourth hypothesis, regarding students' general ability, was supported as Completers had significantly higher *university entrance scores* than did Noncompleters (351.9 vs 340.1, t(71) 1.92, p.<.05).

TABLE 3

Comparison of course Completers and Noncompleters by university entrance score

	N	University entrance score		Significance
		x	*(sd)*	
Completers	49	351.9	*(28.4)*	p<.05
Noncompleters	32	340.1	*(26.0)*	

Initial perceptions. A series of t-tests were conducted in order to determine whether initial perceptions and expectations, such as study time estimate [theory, practical work; hypothesis (v)], confidence in ability to complete the course, expected level of achievement in computer programming [hypothesis (vi)], and perceived relevance of the course and interest in the course [hypothesis (vii)], were related to course completion. Table 4 shows the initial perceptions and expectations of Completers and Noncompleters.

TABLE 4

Initial perceptions and expectations of Completers and Noncompleters

	Completers		Noncompleters		Significance
	x	*(sd)*	x	*(sd)*	
Estimated hours per week studying theory	5.3	*(2.9)*	5.6	*(3.5)*	n.s.
Estimated hours per week undertaking practical work	6.0	*(2.8)*	4.9	*(3.6)*	p<.05
Confidence in ability to complete the course	4.5	*(0.7)*	4.1	*(0.8)*	p<.05
Expected level of achievement in computer programming	4.0	*(0.7)*	3.7	*(0.8)*	p<.05
Perceived relevance of the course to overall programme of study	3.0	*(1.0)*	4.4	*(0.9)*	n.s.
Interest in the course	3.9	*(0.9)*	4.0	*(0.8)*	n.s.

The fifth hypothesis was addressed by examining students' estimates of the time required to study theory and time required to undertake the practical work separately. As expected, Completers' mean estimate of the *time required to complete the practical work* was significantly different (higher) from Noncompleters (6.0 vs 4.9, t(71) 1.81, p<.05) but this was not the case for the expected *time required to study the theory*.

The sixth hypothesis was supported. Completers' mean rating of *confidence in ability to complete the course* was significantly different from Noncompleters (4.5 vs 4.1, t(74) 2.42, p<.05). The same results emerged for anticipated level of *achievement in computer programming* (4.0 vs 3.7, t(80) 1.94, p<.05).

The seventh hypothesis was not supported as there were no significant differences between Completers and Noncompleters in ratings of *relevance to their programme of study or interest in the*

course. It was anticipated that Completers would perceive the course as more relevant and more interesting yet this was not found to be the case. The results were unexpected, as Noncompleters gave much higher ratings of relevance than did Completers.

Perceived importance of factors in contributing to success in the course. Table 5 shows Completers' and Noncompleters' ratings of the importance of a set of factors in contributing to their success in the course.

TABLE 5

Completers' and Noncompleters' perceptions of importance of selected factors in contributing to their success in the course

	Completers		Noncompleters		Significance
	x	*(sd)*	x	*(sd)*	
Internal					
Own ability	4.1	*(0.7)*	4.3	*(0.8)*	n.s.
Hard work	4.4	*(0.8)*	4.7	*(0.5)*	p<.05
External (physical)					
Good materials	4.4	*(0.7)*	4.6	*(0.8)*	n.s.
Difficulty of course	3.4	*(1.0)*	3.7	*(0.8)*	n.s.
External (social)					
Help from tutor	3.3	*(1.0)*	3.7	*(1.1)*	p=.055 marg.
Help from friends/family	2.2	*(1.3)*	2.7	*(1.3)*	p=.064 marg.

As can be seen in table 5, Noncompleters' ratings tended to be systematically higher than those of Completers, although not always significantly. The differences between Completers and Noncompleters on the measures of *hard work* (4.4 vs 4.7, t(104) 2.46, p<0.05), *help from tutor* (3.3 vs 3.7, t(77) 1.95, p=.055) and *help from friends/family* (2.2 vs 2.7, t(84) 1.87, p=.O64) agree with Noncompleters' lower ratings of confidence and expected level of achievement (see table 4). Right from the beginning of the course, Noncompleters were concerned about their achievement, anticipated

that they would need to work hard to complete the course and that any forms of help could make a difference. The lack of significant difference on the measure of *own ability* suggests that Noncompleters were not questioning their own capacity to handle the concepts but rather were concerned about the lack of social support available should they require some help.

Can students' completion or non-completion of a distance education introductory programming course be predicted? (Second research question.)

Logistic regression was used to determine whether information collected from students during the first week of semester could be used to predict whether students would successfully complete the course or not. The SPSS Regression Logistic procedure was used to perform the analyses. A number of logistic regression models were considered, using the variables relating to the hypotheses for the first research question. Interactions were tested for, but none was found to be significant.

The model with the best explanatory capability was:

Prob (completing) =

$$\frac{e^{-16.0229 + 1.232*\text{CONFID} - 1.0889*\text{RELEV} - 0.7873*\text{TUTHELP} + 0.0551*\text{ENTRANCE-SCORE}}}{1 + e^{-16.0229 + 1.232*\text{CONFID} - 1.0889*\text{RELEV} - 0.7873*\text{TUTHELP} + 0.0551*\text{ENTRANCE-SCORE}}}$$

where:

CONFID is confidence in ability to complete the course

RELEV is the perceived relevance of the course to the overall programme of study

TUTHELP is die perceived importance of help from the tutor

ENTRANCE-SCORE is the University entrance score of the student

As shown in table 6 this model correctly classified 82.5% of students (Model $\chi^2(4)$ 33.4, p=0.000).

As an aim of the study was to be able to generalise from this sample of students to students studying introductory programming in the future, an attempt was made to validate the predictive capability of the model using a holdout set of data obtained from students taking the course in the following year. As shown in table 7, a 65.5% success rate in prediction was obtained with the holdout sample of 29 students. A Z-test of proportions (Z 1.67, p<.05) showed that the success of prediction obtained with this model was in fact significantly better than chance (51.5% of this group).

TABLE 6

Classification of predictions

Actual	N	Predicted Group Membership		Per cent correct
		Noncompleters	Completers	
Noncompleters	25	20	5	80.0%
Completers	38	6	32	84.2%
Overall				82.5%

TABLE 7

Validation of the model using a holdout sample

Actual	N	Predicted Group Membership		Per cent correct
		Noncompleters	Completers	
Noncompleters	12	9	3	75.0%
Completers	17	7	10	58.8%
Overall				65.5%

Discussion

Overall, this study found that students who successfully completed a distance education introductory computer programming course could be differentiated from those who did not complete it, at the beginning of their study, and in terms of some demographic characteristics, entering expectations, and initial perceptions of the course. These differences may facilitate identification of students at risk of non-completion so that additional support can be provided.

Who succeeds?

As anticipated, successful completion of the distance education introductory programming course was not found to be related to students' age or gender. The results of this study support the findings from studies involving internal classes in computer programming (e.g. Dalbey & Linn 1985; Volet & Lund 1994). However, a post-hoc analysis showed that females anticipated that the course would be more difficult than did males (3.74 vs 3.16, $t(55)$ -2.95, $p<.01$) despite comparable levels of general ability and background in computing. This is consistent with research on male and female attitudes in internal computer programming courses (e.g. Clarke & Chambers 1989).

The results of this study also agree with those of Volet and her colleagues (Volet & Lund 1994; Volet & Styles 1992) who found no relationship between age and performance in an internal introductory programming course. However, the present study had a very small number of students under 20 years of age, so this conclusion should be viewed with caution.

The hypothesis that students with *prior experience of studying externally* are more likely to complete the course than those for whom the course is their first experience of distance education was not supported in this study. This could be explained by the fact that many of the students had little experience of external study. One or two semesters of experience in distance education - which may have consisted of only one or two courses since external students can only study part-time - would have provided minimal experience of studying externally. In addition, prior experience does not necessarily mean successful prior experience. It is also possible that studying computer programming is sufficiently different from studying other disciplines that the students' prior experience studying other non-programming courses externally did not prepare them for the difficulty of studying programming.

Students with some *previous computer programming experience* were found to be more likely to complete the course than those without experience. This result is consistent with other studies involving on-campus courses in introductory computer programming (e.g. Kersteen et al. 1988; Volet & Styles 1992). Previous exposure to computer programming can be expected to be even more of an advantage to distance education students as it would grant them insight into the nature of the course, enabling more realistic expectations of the work involved. It is possible that it would also make students less dependent on help from tutors and other students, mitigating the difficulties of distance education. Kember et al (1992) found a relationship between the background characteristics and social and academic integration variables, which in turn relate to progress variables suggesting that the way students adapt to study is influenced by pre-entry characteristics. Previous programming experience may facilitate students' adaptation to the course.

The hypothesis that students who are *majoring in computer science* are more likely to complete the course than those who are not was not supported in this study. This is in contrast to the results of Volet and Lund (1994) who found programme of study to be a significant predictor of introductory

programming students' performance. Given that computer programming courses have a reputation for difficulty, and that this difficulty is compounded by external study, it appears likely that students who are not computer science majors enrol in these courses only if they have a strong personal interest in computing or perhaps professional reasons for taking such courses. Further research should investigate further the profile of non-computing majors in computer programming, in particular the extent to which external students may be professionals working part-time in positions which require computer programming knowledge. The immediate need and relevance for such skills would explain their comparable rate of completion with computing majors.

Students with high *university entrance scores* were found to be more likely to complete the course than students with low scores. This is consistent with a number of studies that have shown that students of high general ability perform well in on-campus programming classes, although the relationship between general ability and success at programming is thought to be moderated by learning style (Dalbey & Linn 1985).

The hypothesis relating to *estimates of time required to study* (hypothesis (v)) provided some interesting results. There was no significant difference between those students who successfully completed the course and those who did not with respect to their estimates of the time required to study the theory of the course. The theory component of the course involved an introduction to the syntax of the programming language and a program design methodology. Presumably, students' prior experience of study enabled them to make fairly realistic estimates of the time that would be involved in reading and taking notes from the assigned chapters of the textbook.

There was however, a significant difference in the estimates of the time required to undertake the practical component of the course between those who completed the course and those who did not.

Those who successfully completed the course made higher initial estimates. Studying computer programming requires a large investment of time spent at the computer actually writing, testing and debugging programs. Students who have not anticipated the potentially large investment in time that can be involved in programming may be unable to make the necessary adjustment in order to be able to complete the course successfully. The fact that external students are often characterised by the fact that they have family or work commitments which prevent them from attending classes on campus rather than by geographical isolation could explain these results. Potential students should be made aware of the need to allocate sizable amounts of time to programming so that they can make a realistic determination of their capacity to undertake a programming course, and make adjustments to their overall study load and/or employment if required. This issue should be addressed in the documentation students receive about studying computer programming externally.

Students who were more *confident in their ability to complete* the course and those who perceived that they would attain a higher level of *competence in programming* were found to be more likely to complete the course successfully. These results are in line with recent research on the significance of students' situation-specific cognitive and affective appraisals of study on their learning goals and performance (Boekaerts 1994; Volet 1997). In a study of perceptions of barriers to success and of learning styles of distance education students in general, Gibson and Graff (1992) attributed the key differences between students who successfully completed a distance education course and those who did not to perceptions of confidence and competence, and to commitment. In addition, a number of researchers who have investigated students' persistence and achievement in on-campus introductory computing courses have pointed to the importance of motivational factors (e.g. Clarke & Chambers 1989; Kersteen et al. 1988; Volet & Styles 1992). This study extends the research on face to face teaching of programming to the distance education domain. Expressions of lack of confidence and lack of competence by beginning students in computer programming should perhaps be treated as a warning sign that additional support should be provided.

The significance of *personal interest and perception of relevance* to learning processes and achievement has received increased attention in recent years (Schiefele, Krapp & Winteler 1992). In the domain of studying computer programming, Volet and Styles (1992) found that changes in students' perceptions of interest during the first part of an introductory computer science course were associated with changes in the levels of their content-related goals, in that increasing interest was associated with increasingly higher content-related goals and vice versa. The fact that students' goals were a better predictor of performance than entering background in computing or programme of study indicates that interest is an important aspect of study. The lack of difference in the perceptions of interest and relevance between Completers and Noncompleters in the present study may be due to the fact that these variables were measured at the beginning of the semester.

The issue of the significance of students' *interactions with peers* is well established in the educational and psychological literature on small group learning, cooperative goal structures and collaborative learning processes. Lack of contact with peers is particularly critical in the case of distance education. Anecdotal evidence indicates that many students realise that important opportunities for monitoring their understanding and learning progress are missed (Davies & Preece 1990). In this study it was found that Noncompleters anticipated that help from tutors and friends/family would be more important to their success than did Completers, although the difference was only marginally significant. However, no firm conclusions should be drawn from this result as initial perceptions of need for contact and help may not be the best indicators of their actual importance during the course, especially if it is the students' first experience of external study.

Can success be predicted?

One important issue for providers of distance education courses is to be able to identify students at risk in order to provide early appropriate assistance. This is particularly crucial in the case of external study because of the lack of face to face opportunities to gauge students' progress and provide immediate feedback and appropriate support. While university entrance examinations are expected to provide reliable measures of students' general potential to succeed at university, there is also evidence that such measures are not sufficient to predict students' performance in specific courses of study. Other personal and contextual variables also contribute to explain why some students fail to achieve their potential or alternatively perform better than could be expected on the basis of traditional tests: or example, effort (Volet 1997); computing experience (Clarke & Chambers 1989).

In the present study, it was found that, in addition to university entrance score, external students' initial level of confidence in their ability to pass the course and perceived importance of the need to get help from their tutor each contributed significantly to predicting students' completion or non-completion of the introductory programming course. This finding deserves special focus as it draws attention to some of the unique characteristics of studying at a distance, namely the need for students to be self-confident and to a large extent self-reliant. The significance of self-cognitions and self-regulatory learning strategies for successful distance education has been stressed by Vermunt (1994).

It is difficult to explain the finding that students' perceptions of the relevance of the course to their programme of study contributed to predicting course completion but in the opposite direction to that anticipated. The possibility was explored that students who had a computing background from high school, and therefore would have been better prepared for the present course, may have found it less relevant because the content was partially familiar. Post-hoc analyses of the possible relationship

between students' programming background and perception of relevance showed that this was not the case. This issue needs to be addressed in future research.

One purpose of the present study was to investigate whether students' completion or non-completion of a distance education introductory programming course could be predicted on the basis of a range of personal variables, including entering expectations and initial perceptions of the difficulties involved in completing the course. The capacity of the logistic regression model to correctly classify 82.5% of students compares favourably with Sweet (1986) and Gibson and Graff (1992), who were able, using discriminant analysis, to successfully predict success or failure of respectively 77% and 71% of their cases. From an educational point of view it was interesting to note that the prediction errors were primarily in the direction of falsely predicting failure of students who subsequently passed. If these students are at risk of failing it may still be worth identifying them at the start of the semester so that extra support can be provided.

Implications of the study

This study suggests that it may be possible to identify distance education students who are potentially at risk in their introductory computing course. The small amount of time and effort required to survey introductory computing students could be a valuable investment. Students with no background in computing, a mismatch between time needed and time available for practical work, lack of confidence, or low expectations of achievement could be quickly identified and contacted individually to discuss strategies for mitigating risk factors. These strategies could include rescheduling work or other commitments, more formalised contact arrangements with the tutor, and setting up of support networks with peers having similar concerns.

Today there is a rapid increase in distance education through the potential of new technologies such as the World Wide Web, teleconferencing and other communications technology to provide educational resources and learning support. However, the significance of human factors in contributing to an individual's academic achievement should not be underestimated. Studies such as these are valuable in identifying the general and course-specific factors that should be addressed in distance education to ensure that these new technologies are used to maximal advantage.

References

Aveling, N., Smith, S. & Wilson, C. 1992, 'Meeting the needs of isolated students: Is a technological fix the answer?', in *Academia Under Pressure: Theory and Practice for the 21st Century*, vol.15, ed. E. Parer, HERDSA, Churchill, Vic.

Bernard, R.M. & Amundsen, C.L. 1989, 'Antecedents to dropout in distance education: Does one model fit all?', *Journal of Distance Education,* vol. 4, no. 2, pp. 25-46.Bernt, F.M. &

Bugbee, A.C. 1993, 'Study practices and attitudes related to academic success in a distance learning programme', *Distance Education,* val. 14, no. 1, pp. 97-112.

Boekaerts, M. 1994, 'Action control: How relevant is it for classroom learning?', in *Volition and Personality: Action Versus State Orientation,* eds J. Kuhl & J. BecJcman, Hogrefe and Huber Publishers, Bern, pp. 427-35.

Brooks, R. 1990, 'Categories of programming knowledge and their application', *International Journal of Man-Machine Studies*, no. 33, pp. 241-6.

Canas, J.J.., Baja, M.T. & Gonzalvo, P. 1994, 'Mental models and computer programming', *International Journal of Human-Computer Studies,* vol. 40, no. 5, pp. 795-811.

Clarke, V.A. & Chambers, S.M. 1989, 'Gender-based factors in computing enrolments and achievement: Evidence from a study of tertiary studies', *Journal of Educational Computing Research*, vol. 5, no. 4, pp. 409-29.

Coldeway, D. 1986, 'Leamer characteristics and success, in *Distance Education in Canada*, eds I. Mugridge & D. Kaufman, Croom Helm, London, pp. 81-93.

Dalbey, J. & Linn, M. 1985, 'The demands and requirements of computer programming: A literature review' *Journal of Educational Computing Research*, vol. 1, no. 3, pp. 253-74.

Davies, G. & Preece, 1. 1990, 'Home computing as an integral part of distance education', *Education and Computing*, no. 6, pp. 153-9.

Garland, M.R. 1993, 'Student perceptions of the situational, institutional, dispositional and epistemological barriers to persistence', *Distance Education*, vol. 14, no. 2, pp. 181-98.

Gibson, C.C. & Graff, A.O. 1992, 'Impact of adults' preferred learning styles and perception of barriers on completion of external baccalaureate degree programs', *Journal of Distance Education*, vol. 7, no. 1, pp. 39-51.

Glatter, R. & Weddell, E.G. 1971, Study by Correspondence, Longman, London. Harper, G. & Kember, D. 1986, 'Approaches to study of distance education students', *British Journal of Educational Technology*, vol. 17, no. 3, pp. 212-22.

Harrington, F. 1979, The Future of Adult Education, Jossey-Bass, London. Jennings, PJ. & Atkinson, RJ. 1982, 'Learning computer programming at a distance', *Distance Education*, vol. 3, no. 1, pp. 157-69.

Jones, D. 1996, 'Computing by distance education: Problems and solutions', *SIGCSE Bulletin*, no. 28, pp. 139-46.

Kaeley, G. 1993, 'Explaining mathematics achievement of mature internal and external students at the university of Papua New Guinea', *Educational Studies in Mathematics*, no. 25, pp. 251-60.

Kember, D., Lai, T., Siaw, I. & Yuen, K.S. 1992, 'Student progress in distance education: Identification of explanatory constructs', *British Journal of Educational Psychology*, no. 62, pp. 285-98.

Kersteen, Z.A., Linn, M.C., Clancy, M. & Hardyck, C. 1988, 'Previous experience and the learning of computer programming: The computer helps those who help themselves', *Journal of Educational Computing Research*, vol. 4, no. 1, pp. 321-33.

MacCallum, J. 1995, Collaborative learning in distance education, paper presented at the Australian Association for Research in Education Conference, Hobart, Tasmania.

McGill, T. & Hobbs, V. 1996, 'A supplementary package for distance education students studying introductory programming', *SIGCSE Bulletin*, vol. 28, no. 1, pp. 73-7.

McIntosh, N.E., Woodley, A. & Morrison, V. 1980, 'Student demand and progress at the Open University — the first eight years', *Distance Education*, vol. 1, no. 1, pp. 37-60.

Peters, O. 1992, 'Some observations on dropping out in distance education', *Distance Education*, vol. 13, no. 2, pp. 234-69.

Roberts, D. 1984, 'Ways and means of reducing early student drop-out rates', *Distance Education*, vol. 5, no. 1, pp. 50-71.

Schiefele, U., Krapp, A. & Winteler, A. 1992, 'Interest as a predictor of academic achievement: A review of research', in *The Role of Interest in Learning and Development*, eds K.A. Renniger, S. Hidi & A. Krapp, Erlbaum, Hillsdale, NJ, pp. 183-212.

Sweet, R. 1986, 'Student dropout in distance education: An application of Tinto's model', *Distance Education*, vol. 7, no. 2, pp. 201-13.

Tinto, V. 1975, 'Drop-out from higher education: A theoretical synthesis of recent research', *Review of Educational Research*, vol. 45, no. 1, pp. 89-125.

Vermunt, J. 1994, 'Design principles of process-oriented instruction', in *Process-oriented Instruction and Learning from Text*, eds F.P.C.M. de Jong & B.H.A.M. Van Hout Wolters, VU University Press, Amsterdam, pp. 15-26.

Volet, S.E. 1997, 'Cognitive and affective variables in academic learning: The significance of direction and effort in students' goals', *Learning and Instruction*, vol. 7, no. 3, pp. 235-54.

Volet, S.E. & Lund, C.P. 1994, 'Metacognitve instruction in introductory computer programming: A better predictor of achievement than traditional factors', *Journal of Educational Computing Research*, vol. 10, no. 4, pp. 297-328.

Volet, S.E. & Styles, I.M. 1992, 'Predictors of study management and performance on a first-year computer course: The significance of students' study goals and perceptions', *Journal of Educational Computing Research*, vol. 8, no. 4, pp. 423-49.

Weiner, B. 1979, 'A theory of motivation for some classroom experiences', *Journal of Educational Psychology*, vol. 71, no. 1, pp. 3-25.

Wong, S.-L. 1992, 'Approaches to study of distance education students', *Research in Distance Education*, vol. 4, no. 3, pp. 11-17.

Woodley, A. & Parlett, M. 1983, 'Student drop-out', *Teaching at a Distance*, no. 24, pp. 2-23.