STUDENT NON-COMPLETION ON ICT PROGRAMMES

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BRIEFING PAPER:

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Introduction

This Briefing Paper reports on findings from the National Forum funded research project on student non-completion on ICT programmes led by a team based at the University of Limerick[1]. The Paper summarises international literature on student non-completion with a focus on students of ICT ; it outlines proven initiatives and pedagogic practices designed to tackle ICT student non-completion and it presents the results of exploratory case study research on ICT non-completion at the University of Limerick. It also includes further considerations arising specifically from the institutional case study as well as those arising more generally from the question of non-completion in the Irish context.

1.0 Student Non-Completion

1.1 Non-Completion in Higher Education

Student non-completion is a significant issue for higher education internationally and has been intensively researched in a range of international contexts. This is evidenced by the four decades of research that has grown from early studies in the 1970's and 1980's focused on individual characteristics of students, to more holistic studies from the 1990's onwards which have examined the wider set of factors within and outwith the classroom in higher education (Tinto 2006). Large scale national studies have generated a broad understanding of the various factors affecting student non-completion, retention and progression in higher education,indicatively: lack of preparation for higher education (HE), incompatibility; between the student and the academic programme; academic challenges and poor academic progress (Yorke & Longden 2008).

Moore-Cherry and Quinn (2015) provide a detailed and updated review in the Irish setting that gives a broader view of the reasons for non-completion[2]. This national analysis of the

[1] The research was led by Dr Michael English and Dr Hussain Mahdi, University of Limerick. The project team was as follows: Dr. Arash Joorabchi, Clem O'Donnell, James Murphy, Dr. Fiona Farr, Dr. Olivia Fitzmaurice, Professor Paul Conway, of the University of Limerick, and Dr, Michael Madden and Christopher Loughnane, of NUI Galway.

[2] An annotated review of the range of literature that identifies the general causes of non-completion is beyond the scope of this report, and there are many national and international sources that outline and explore these causes. For further information please see the references.

factors affecting student non-completion showed that the key causes included those relating to: programme issues; personal issues; financial matters; health/medical/family issues. When programme choice is cited as a factor associated with non-completion, in the study students variously include reference to the nature of the academic and learning experiences, social integration and the quality of institutional support services.

While the general causes of non-completion are not irrelevant to the more specific group that is the focus of this report, there are certain causes of non-completion that relate more particularly to students on ICT programmes. It is these causes that are explored in more detail in the remainder of this briefing paper.

1.2 Student Non-Completion on ICT Programmes

The following presents some of the themes arising commonly in the research literature.

Prior ICT knowledge. There is generally a substantial difference in the level of student exposure to ICT subjects from school to school, depending on resource and expertise availability, and this has consequences for the academic and learning experience at university. In Ireland the absence of computing among the formal subjects for the Leaving Certificate has been identified as a substantial issue (Connolly & Murphy 2005). There tend to be variable levels of exposure to ICT competency among students entering university which can have negative impacts on self-efficacy, self-confidence and self-esteem among students, generating further challenges for lecturers and others supporting students in HE.

Understanding ICT Programme. Research has shown that there is often a lack of student awareness of what the study of ICT or Computer Science (CS) programmes entails, leading to misconceptions about the subject mastery required to be successful (Beaubouef & Mason 2005). Students' beliefs that high self-efficacy in general computing skills, (such as word processing, spreadsheet usage, web browsing, and playing computer games), prior to starting university suggests an aptitude for ICT/CS, points to a poor awareness of the level of maths and computer skills necessary to succeed in such programmes. This issue is exacerbated if there has been a lack of programming and problem-solving programmes available to students prior to HE (Moskal et al 2004; Biggers et al 2008).

Programming skills. For ICT students, and particularly CS students, it is accepted that learning to program is difficult. High failure rates and low retention rates, with high overall attrition from these programmes, particularly in the early stages have been reported internationally (Bennedsen & Caspersen 2007). Attrition rates from CS programmes during the first two semesters are often between 30% and 40% and can be as high as 50% during the first semester (Beaubouef et al 2001; Beaubouef & Mason 2005). Failure rates in introductory programming modules have been reported as being between 20% and 50% (McKinney & Denton 2004; Sloan & Troy 2008).

Learning to program requires significant practice. However large classes, limited computer laboratory resources along with limited time for student mentoring to facilitate students in developing key programming skills create conditions that do not provide sufficient time for students to practise (Crenshaw et al 2008). All of these issues, combined with the particular needs of first year students, can result in further discouragement for students (Beaubouef & Mason 2005).

Academic skills. Programming projects require students to perform complex tasks using high level skills in analysis, design, coding and testing, even in the early stages, and for students without project management skills this can be demanding, time consuming and ultimately frustrating (Biggers et al 2008). Additionally many students fail to appreciate the wider range of skills required in practice in ICT including language and communication skills and technical writing skills (Beaubouef et al 2001) .

Mathematics. The limited mathematics skills and problem-solving abilities of some students entering ICT programmes is of significance as competencies in these areas underpin the scientific computations and data relationships necessary for designing algorithms. Research suggests that students with high mathematics competencies tend to do better in ICT programmes (Beaubouef 2002; Moskal et al 2004). Initiatives to foster and practice problem-solving at a basic level prior to and early in these students' programmes is seen as a prerequisite to achieving success within CS programmes. Learning programming can be an intimidating experience for some students, and when students experience 'programming anxiety', these difficulties can lead to them leaving their studies (Connolly et al 2009).

Social Integration. Many early stage ICT students report a lack of what Crenshaw (2008) calls community identity, and ICT programmes are sometimes lacking in socialisation aspects which can foster the development of such identities. Biggers et al (2008) have highlighted "low levels of human interaction" within ICT programmes, exemplified by a lack of peer-to-peer interaction, peer mentoring and learning. In combination with solitary and antisocial aspects of learning to program within ICT programmes this can lead to frustration and student attrition.

Student Profile. Another consideration is the important issues of recruitment, under-representation and retention of female students on ICT programmes. Patterns of gendered non-completion seem to indicate that support in the learning environment, which include mentoring, female role models and female peer mentoring, are important (Cohoon, 2002). It has also been suggested that the impact of transition on female students, in particular, may be significant on ICT programmes and thus require particular attention (Miliszewska et al 2006).

1.3 Initiatives for Tackling Non-Completion on ICT Programmes

As well as the broad retention strategies design to support the progression of students across all disciplines, ICT programmes tend to have specific retention issues which require tailored approaches and initiatives to address them.

Pedagogical and curriculum development.

Pedagogical and curriculum development is important in terms of student retention. Jones (2008) notes that learning, teaching, assessment and programme content are at the core of the student experience, and that pedagogical and curriculum development have a central role to play in both student retention and student success. Examples include:

- The flipped classroom model whereby students are expected to learn content on their own time (generally via computer-based individual instruction outside the classroom) and where contact time is used to engage in student-centred learning activities, such as problem-based learning and inquiry-oriented strategies (Butt 2014; Findlay-Thompson & Mombourquette 2014).
- Gamification as defined by Deterding et al. (2011) has been championed in the retention literature as an active, student-centred and engaging design for instruction and learning. Certain underlying concepts found in game design are shown to be consistently successful

when applied to learning environments (Cronk 2012; Stott & Neustaedter 2013). These concepts include:

- Freedom to fail: allowing learners multiple chances or "lives" motivates learners to explore without the fear of failure, and increases student engagement.
- Progression/Interest: showing students how they will progress, and maintaining their interest through purposeful sequencing events to maximise student engagement.
- Frequent feedback is a feature that games tend to have more than traditional learning environments. The frequency and the intensity and quality of feedback is a critical element in learning.
- A foundation programming programme, possibly using a visual programming environment (VPE) such as Scratch (a visual programming language) or Alice (a visual programming tool) (Mullins et al 2009; Rizvi & Humphries 2012).Visual programming allows the creation of simple games and animated stories while teaching fundamental programme concepts. The outputs are visually appealing objects, rather than the numbers and characters of traditional programming language, which provides learners with immediate feedback about their programming functionality (Siiman et al 2014).

Learning Support Specialised support centres can provide students with access to additional one-to-one and group support, beyond their programme provision, for subject-specific learning including Maths and ICT. Providing the opportunity for students to learn the underlying concepts of programming in a hands-on fashion may have an impact on student success in difficult modules (Naughton et al, 2010). Strategies for predicting factors which seem to indicate the likelihood of student success in early programming modules may be vital in helping to identify students who require support (Bergin & Reilly 2005; 2006).

Active Student Centred Collaborative Learning Programmes

The positive effects of active collaborative learning on student engagement and retention have been well documented (Tinto 1997; 2000; Zhao & Kuh 2004). Collaborative learning programmes can foster a sense of belonging to the programme, department and institution. In ICT/CS programmes, they are often used to encourage community building through the use of peer groups and project work to facilitate learning. More specific examples of student-led

or student-supported approaches include pair programming[3] (PP) and peer-learning. While the results of studies designed to examine the efficacy of PP are mixed there are indications that the use of PP may have a positive effect on student engagement and retention within ICT/CS programmes (McDowell et al 2002; Williams et al 2003; Mendes et al 2005; Braught et al 2011).

Flexible and Inclusive Learning Environments and Pathway

Flexible pathways to allow students to avail of different points of access to ICT programmes are important (Jenkins, 2002). Increasing student diversity and growing differences in students' prior knowledge and abilities need to be accommodated in terms of multiple pathways in first year ICT programmes (Roberts &McGill, 2013). Inclusion of a wider diversity of students also has implications for creating an overall sense of belonging (Connolly & Murphy 2005).

2.0 Impact of SALS (Supplementary Academic Learner Supports) Initiatives: A case study from the University of Limerick

An exploratory study was conducted to investigate the relationship between students' participation in and engagement with the ICT SALS (Supplementary Academic Learner Support) services, and the progression of first-year students in undergraduate ICT programmes at the University of Limerick (UL). Three services offered by the ICT Learning Centre (ICTLC) and the Peer-Supported Learning Centre (PSLC) were examined:

1. Drop-In sessions;
2. Targeted sessions (ICT Targeted Module Sessions; Targeted Skills Workshops; Core Programming Training Programmes),
3. Peer Supported Learning Group (PSLG) sessions.

Analysis of historical data from UL's student record systems (2009-2014) along with student feedback on SALS Services (2010-2014) was undertaken to explore first-year students' participation and engagement with the SALS services and subsequent progression to the 2nd

[3] Pair programming refers to the practice whereby two programmers work together at one computer, collaborating on the same design, algorithm, code, or test. The pair is made up of a driver, who actively types at the computer or records a design; and a navigator who watches the work of the driver and attentivelyidentifies problems and makes suggestions. Both are also continuous brainstorming partners. (Williams, 2003:143).

year of their programmes of study. A supplementary survey of current students (2014/15) was also undertaken.

2.1 Analysis of Student Data from the University's Student Record Systems: 2009-2014

Four core ICT programmes were chosen; two from each of the main ICT-focused academic departments at UL. The data set included a total of 736 first-year students, over a period of five years, enrolled on the four programmes. Table 1 summarises student numbers on all four programmes over five years and details their level of engagement with the SALS services.

Table 1: First Year ICT students' engagement with SALS services 2009-2014

Academic Year	Number of Students	Percentage of students who attended at least one support session
2009-2010	128	66%
2010-2011	120	48%
2011-2012	143	59%
2012-2013	174	70%
2013-2014	171	53%

Analysis of student record data, students' engagement with the SALS services and progression to year 2 of their programme data indicated that:

i. Overall, the level of engagement for all of the 736 first year students with SALS services showed that, on average over the five years, 60% availed of the SALS services at least once in each of the five academic years.

ii. On average, students who engaged with the SALS services progressed at a rate 19% higher than their 'Not Engaged' colleagues (77% vs 58%).

iii. The progression rate of 'at risk'[4] students who engaged with the services was significantly higher than that of 'at risk' students who did not engage (on average 26% higher progression rate).

iv. On average, students who engaged with the SALS services exhibited higher rates (16%) of passing their core programming modules in both semesters of the first year. The data also showed a significant correlation between the use of the services and the achievement of an A grade in both modules.

[4] A student is identified as an 'at risk' student if s/he attains a final grade of C or lower in their core ICT/programming module in the First Semester, while a 'Not At Risk' student is one who attained a final grade which is higher than C in that module.

v. Students' CAO points were analysed to see if there was any relationship between CAO points and students' 1st to 2nd year progression rates. The analysis across each academic year of the bottom 25% of students (ranked by CAO points), showed that between 72% and 86% of this cohort of students were classified as 'at risk', and of this 'at risk' group, between 49% and 70% did not progress to the 2nd year of their programme.

2.2 Student feedback on SALS Services Academic Years 2010-11 to 2013-14

At the end of each of the four academic years, between 2010 and 2014, students gave feedback via an online survey on their satisfaction with and their perceptions of the core SALS offerings (Drop-Ins, PSLGs and Targeted Sessions). The process involved gathering data for a total of 736 first-year students enrolled on the four chosen programmes over five academic years. Open-ended responses of students' perceptions of the supports they had experienced, seem to demonstrate that interactions which involved opportunities to learn collaboratively in small groups with peers and to work on difficult material were valued highly, for example:

'*It is a great environment to do work and collaborate.'*
'Helped with my problem solving and critical thinking.'
'I got to meet other people from my programming module and made friends.'
'Learning the difficult material of the course as it was a small group'
'In small group numbers it's easier to explain finer details and ask questions.'

Student Feedback Responses

It is worth noting that the aspects of the learning environment and support offered to students through the SALS Service, received positively by the students resonates with both the ICT specific issues identified in the literature. These included collaborative learning, developing a wider repertoire of transferable skills, becoming part of a peer community and engaging with difficult material.

2.3 Online Survey of Current Students on ICT Programmes(2015)

A survey was designed and implemented in 2015 to explore the perspectives and experiences of students currently enrolled on the selected ICT programmes and factors affecting student retention prospects. Conducted among the first year ICT students in academic year 2014/15,

n= 78, the survey included 37 questions which were clustered into 3 categories: background information; expected and current academic status; and interaction with SALS services. A total of 78 students completed the survey with the majority indicating that their current programme of study was their 1st choice. Only 8% indicated it was their 2nd choice while for 5% it was their 3rd choice or lower. In terms of availing of SALS Services, 42% of respondents stated that they had done so at least once. Closer analysis of the data highlighted the following themes:

i. **Students at Risk**. Students whose expectations matched with their programme experience were less likely to be 'at risk'. In addition they also seemed to avail of the SALS services more readily. Where students ranked their perceived skills in maths, writing, communications and computer programming, analysis seemed to suggest that students who considered themselves to be weak at maths and programming are more likely to be at risk than those who considered themselves to be strong in these areas. Students who considered their programming skills to be weak were twice as likely to avail of the SALS services as those who considered their programming skills to be strong.

ii. **Students thinking of leaving.** In all, 33% of students indicated that they had considered leaving the programme and of these 65% were in the 'at risk' category. 23% of students who had considered leaving their programme of study had availed of the support services. 27% of those who had not considered leaving their programme availed of the services.

iii. **Four of the top five ranked reasons for considering leaving the programme were ICT-domain specific.** By far the most highly ranked reason for considering leaving was 'subject difficulty'. 74% of respondents indicated that they had encountered difficulties with particular modules in the first semester: Of these, 44% reported difficulties with an ICT module (e.g., computer organization, computer software, electrical engineering); 33% had difficulty with a maths module (e.g., computer maths, engineering maths).

iv. **The highest ranked difficulty was, 'new material to process'.** The highest ranked reason for students considering leaving their programme, was 'subject difficulty'. The other difficulties cited, in order of rank, were: the pace of the programme of study; the nature of the learning experience; the workload; the student not knowing what was expected of them by lecturers/tutors; student lack of ability or prior knowledge of

mathematics/analytics; issues with assignment spacing; and student lack of ability or prior knowledge of basic computing skills.

v. **Influence of 'Family and friends'.** These were the most highly ranked influence on student decisions to continue with their programme of study. The other reasons cited, in order of rank, were: involvement in extracurricular activities; campus community; academic staff/Programme Director; learner supports (e.g ICTLC / PSLC services etc); student advisor; student supports (e.g. medical, counselling, chaplaincy, etc).

vi. **Links between 'at risk' status and SALS engagement.** Of the respondents (42%) who had engaged with the SALS services 40% of these were in an 'at risk' category. Of those students who had availed of the services, 53% had attended the drop-in sessions, 33% had attended the Peer Supported Learning Groups (PSLG's) and 14% had attended the targeted sessions. Respondents rated the Drop-in Sessions most highly for helping them understand difficult material, but the PSLG Sessions more highly for helping them develop broader competencies such as communication skills, learning and study techniques and team work.

The survey was extended to NUIG, with a sample of 35 students, and illustrated some broad similarities in both student cohorts. In terms of the proportion of students in both institutions almost 75% seemed to experience subject related difficulties, of which almost 50% indicated that an ICT subject was their most difficult. Overall in both institutions, almost one third indicated that they had considered leaving their programme of study.

2.4 Further Considerations Arising from the Case Study

While the exploratory case- study has focused on a particular institutional ICT retention initiative - the provision of additional Supplementary Academic Learning Support - it raises some issues that may be of relevance to other higher education institutions in respect of ICT programmes as well as further research.

i. The concerns and experiences of students identified by the 2014/15 survey in relation to subject difficulty and learning experience could suggest that closer partnerships between SALS services, programmes and academic departments as well as Teaching & Learning centres and units may be beneficial in finding collaborative responses to the challenges students face. The principle of identifying 'at risk' students through

analysis of a number of attributes including prior learning and attainment, skills and knowledge and motivations might also inform the focus of such responses.

ii. The perceived difficulty of ICT subjects may also have a cognitive basis and previous studies have examining prior characteristics of successful ICT learners have suggested that learners are more likely to succeed if spatial, visualisation skills, articulation capacities, and learning strategies have been well developed (Simon et al 2006; Moore et al 2003). This may need to be considered in wider educational development activities.

iii. While the contribution of Maths Support provision was not included within the scope of this preliminary study, subject difficulties with maths were highlighted as an important aspect of students' overall confidence and likely success. Coupled with the acknowledged importance of Maths to underpin successful ICT learning generally, further exploration of the benefits of Maths Support in combination with ICT support provisions will be important.

iv. The case study included analysis of student feedback and performance data in relation to ICT programmes. Much longitudinal data is collected routinely within institutions in relation to on-going programme monitoring. It may now be important to consider what data analysis might best support on-going review and enhancement of ICT programmes.

3.0 Issues for further consideration by policy makers and higher education institutions

The section presents some important points for further reflection. While not intended to be exhaustive, these focus primarily on programme and student success. There is a need to ensure that students have adequate opportunities to gain exposure, in a number of contexts, to understand the nature and academic demands associated with ICT/CS programmes. In this regard, there may need to be a reappraisal of current arrangements for second level education preparation; the interface between HEI's and the second level system as well as transition to and learning engagement in higher education.

Preparation at Second Level

Students need to become clear about the requirements of ICT/CS programmes and the distinction between the academic ICT/CS context and their social media day-to-day

experiences of ICT, while at second level. This would facilitate more effective student decision-making in terms of their college/university programme choices.

- Students may require earlier exposure to ICT as part of their second level studies. The development of ICT as a fully resourced subject at second level would most likely encourage two main outcomes. Firstly, students could gain the requisite skills in ICT to provide a sound basis for higher education study of the subject. Secondly, students would also gain understanding of their aptitude and interest in ICT; this could have a positive impact on students' programme selection for entry to higher education.
- Taster programmes and opportunities for second level students to experience some of the ICT subjects should be more widely available and accessible to students considering an ICT programme at higher education level. This could happen through active liaison between higher education institutions and their feeder schools, by the provision of online topic classes, summer schools, or a dedicated institution/learner interface for ICT programmes which provides programming task examples. The voluntary programme CoderDojo, which has grown in popularity over the recent past, can provide learners with an opportunity to learn basic programming and web development. The peer learning philosophy and learning environment allows learners to engage and learn collaboratively with others, developing the foundational key skills necessary for success in ICT settings.

Student recruitment by higher education institutions

Higher education institutions may need to review the recruitment information and recruitment practices for ICT programmes to ensure that these strike an appropriate balance between making programmes attractive to prospective learners and articulating realistically the challenges involved in undertaking such programmes.

- As part of student recruitment initiatives, prospective learners should have the opportunity for peer learning about ICT programmes. This would facilitate an insight into the subjects involved, the academic demands and the components of the learning experience for ICT/CS programmes. For example an open blog by students on a programme would provide a valuable window on the challenges and realities of the learning experience.

- Diagnostic testing is likely to provide prospective students with the opportunity to assess their aptitude for successful engagement with ICT programmes at higher education level as well as providing them with a real introduction to the subjects they will study and the challenges they will face in studying those subjects. This in turn may inform their choice of higher education programme.
- Higher education institutions should also consider how broad-based entry to programmes as well as programme transfer and progression opportunities within institutional cluster could be maximised to support student mobility on ICT programmes.

Student transition to and engagement in higher education

The purpose and structure of Semester 1 should be reconsidered, with a view to creating a low risk learning environment based on a range of formative learning and assessment tasks to facilitate learner transition and adaptation to higher education.

- In the case of ICT programmes this might include an early (semester 1) focus on the development of general underpinning academic skills in programming and maths, academic socialisation as well as student learning strategies required for successful study at higher education level. This could provide opportunities for students to transition and adapt, as well as build personal and academic confidence. Some of the retention initiatives outlined earlier emphasise a range of pedagogical approaches which help to build learners' key skills for ICT programmes. Modules and programmes, particularly in the first year of ICT programmes, should be reviewed to ensure that the pedagogy supports disciplinary induction and maximises student engagement and success.

- In combination with a reformed Semester 1, broad programme entry in the first year should permit students to make an informed choice at the end of first year about the academic path that they will follow in their college/university programme.

- A number of student attributes including prior skills, knowledge and CAO points have a predictive validity which allows 'at risk' students on ICT programmes to be identified. Institutions should review student data to identify 'at risk' students as part

of institutional strategies for early engagement. In addition, learning supports for 'at risk' students should be reviewed to ensure that such supports are seamlessly accessible for students, well integrated and closely monitored.

4. Concluding Notes

Student retention on ICT programmes is a complex and multi-faceted issue and while there is not a single initiative which promises a quick solution, there are a number of steps which should form the basis of an integrated approach. This Briefing Paper has drawn on a survey of the ICT literature on retention; ICT pedagogy and curriculum development and a case study of supplementary learner support at a single Irish institution. From this, the following points are worthy of note:

1. **Programme selection**

   Prior interest in ICT programmes has been found to be a poor predictor of subsequent success (Sheard et al, 2010). The institutional case study research found that those students who were most at risk of non-progression or thinking about leaving their programme had experienced academic difficulties associated with programming and maths in the first semester. Actions to improve the programme selection process and ensure a better match between learners' prior skills and programme requirements will be an important step (Bergin&Reilly 2006).

2. **Student Engagement**

   Some of the literature highlighted that student engagement and support is extremely important in inducting students to ICT as a discipline and its institutional setting. Coupled with the effects of transition to higher education, strategies for peer mentoring and collaborative learning as well as extended induction programmes are important. (Cohoon 2001; Siiman al 2014; Denny 2015)

3. **Pedagogy and curriculum development**

   For students who experienced academic difficulties, as reported in the research literature and institutional case study, these were most commonly in learning to program. Pedagogies and curriculum approaches which create time and opportunity for students to learn by doing, often collaboratively, and gain effective feedback on their programming progress can be valuable. Pedagogic and curriculum development expertise exists in

Ireland to support ICT learning and this needs to be shared further (Mahdi 2006; Connolly et al 2009; Naughton et al 2010)

4. **Supplementary Learning Support**
   Institutional case study research has shown that the provision of learning support can assist students who may be experiencing difficulties in the early stages of their ICT programmes. The provision of small group collaborative learning opportunities to tackle difficult material in the early stages of programmes can have a positive effect on students' progression.

There is now a large body of research on general student retention of over 40 years standing, which has been augmented by work on the specific student ICT retention issues. Commentators such as Tinto (2007) and Yorke (1997; 2008) have drawn attention to the multi-various factors which affect student retention in general and they advocate strongly the value of unifying institutional strategies for developing approaches to student non-completion. Such strategies should be founded on strong institutional commitment to retention, the establishment of supportive student relationships, student involvement and learner support within higher education settings. Higher education institutions in Ireland have already begun to make progress in this regard through retention initiatives, through on-going pedagogic and curricular development, and student support initiatives. This work can be informed further by the ICT specific issues identified through this Briefing Paper.

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