Determining Key Skills for IT Graduates in the Emerging Knowledge-Based Economy

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Abstract

At its meeting in Lisbon in March 2000, the EU council stated that the EU "must become the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion". To achieve this ministers of education agreed on three major goals to be achieved by 2010: to improve the quality and effectiveness of EU education and training systems; to ensure that they are accessible to all; to open up education and training to the wider world. All of these objectives are closely tied to the ethos and institutional strategy of the Dublin Institute of Technology (DIT).

DIT is the lead partner of the Emersion project, funded by the EU Asia-Link programme, working with Harbin Institute of Technology, China and University of Wolverhampton. The aim of the project is to establish, implement and evaluate an industry-oriented education model and system in China, particularly for the information technology sector. The findings will be used to enhance the skills of academic staff in all partner institutions to improve the delivery of IT education to better compete globally as well as locally.

Emersion's aims are very closely tied to those of the EU. As part of this project all three partners surveyed local industry to identify key skills for graduates for the IT sector. DIT School of Computing also surveyed its academic staff. This paper outlines the findings of this survey and discusses their relevance with regard to the stated EU objectives. It provides insights into the delivery of IT education in Ireland and demonstrates that in order to ensure that Ireland remains one of the world's leading IT solution providers it is essential that third level educators be aware of industry trends, both present and future, and continuously adapt educational programmes accordingly.

1. Introduction

At its meeting in Lisbon in March 2000, the European Council identified a strategic goal : to make the European Union by 2010 "the most competitive and dynamic knowledge-based economy in the world, capable of sustainable growth with more and better jobs and greater social cohesion" (EU 2004). An educated, skilled workforce that can create and use knowledge effectively, together with a dynamic, supporting telecommunications infrastructure, are integral to creating and sustaining a knowledge economy capable of competing globally (OECD 2002, World Bank 2002). Developing close and effective co-operation between third level institutes and industry is a challenge that must be addressed in the creation of a knowledge economy (EU 2003). The Lisbon strategy, developed in March 2000, recognises these issues and calls for the co-ordinated effort of a number of organizations, including educational institutes which have key roles in both research and education (EU 2003). Heads of States and Government have asked for modernisation of education systems and stated that by 2010 “Europe should be the world leader in terms of the quality of its education and training systems” (EU 2004). Third-level educational institutes are now faced with the task of constructing education systems to achieve these ambitious objectives.

Ireland underwent a major economic transformation during the late 20th century to emerge and be recognized as one of the world’s up and coming knowledge economies (Florida 2004, OECD 2002). Ireland has already established strong foundations and it is now faced with the challenge of completing its transformation into a fully-fledged, globally competitive, sustainable knowledge economy. Indeed, Ireland is seen by many as a model for developing countries particularly the recent new entrants to the EU. As such Ireland can expect to be a key player in the development of the EU’s knowledge-based economy.

Central to Ireland’s success to date have been its flexible, well-educated graduates who can be integrated rapidly into the workforce (Gallen 2001). Ireland has one of the highest concentrations of information and communications technology activity in the world and in particular Ireland has one of the world’s leading software industries (Gallen 2001, Hickey 1998). Since late 2000 however, the global IT industry has suffered severely and Ireland has been greatly affected. Although recovering, it is unlikely that it will reach its pre-2000 heights. There is currently a large amount of discussion and debate about the strategy Ireland must employ to evolve into a competitive, global knowledge economy. There seems to be agreement that the well established IT sector will play a key part in Ireland’s future but must evolve to meet the new challenges faced (Forfás 2003). The downturn in the IT industry has seen a similar downturn in the numbers of students choosing to study IT related courses at third level (Enterprise Ireland 2004). However, projections indicate that the IT industry can expect to recover in 2004 and that the demand for skilled IT graduates at degree level will significantly exceed supply by 2006 (Forfás 2003). In addition, if Ireland is to truly emerge as a globally competitive, knowledge economy, IT graduates will require skill-sets different to those currently taught in its third level educational programmes (World Bank 2002).

The Forfás Expert Group on Skills Need has identified that the demand for computing graduates of all levels will significantly exceed supply by 2006 and that the demand for graduates at degree level is identified as a particular area of concern (Forfás 2003). The need to address the gap between the skills of graduates and those of industry in the future also represents a challenge to educational institutes. This is closely tied to objectives agreed by the European Council to achieve the aim of the Lisbon strategy that call for educational institutes to make a reality of lifelong learning (EU 2004). Education at all levels will need to demonstrate creativity and flexibility, and achieve higher levels of quality, effectiveness and efficiency (Skilbeck 2003). Third level educational institutes in Ireland are now faced with the necessity to re-assess their delivery of IT education and, with the help of industry, develop a strategy to satisfy requirements of the future knowledge economy. Incorporating a strong industrial focus in education and providing the building blocks to facilitate life-long learning are the primary challenges.

These challenges are particularly relevant to the Dublin Institute of Technology (DIT) which is characterised by a close alliance with and responsiveness to industry. DIT also has a long history of and strong commitment to lifelong learning. DIT constantly evaluates its educational programmes and revises them to meet new challenges it faces. As part of this policy, DIT created a survey aimed at the IT industry in Ireland to investigate the challenges faced in the delivery of IT education. This survey was undertaken as part of the Emersion project established in 2002 (Emersion 2004) as a co-operative effort between DIT, Harbin Institute of Technology, China and University of Wolverhampton, UK and funded by the EU Asia-Link programme (Asia-Link 2004). A stated aim of the project is to enhance the education models in all the partner institutions and its primary aim to establish, implement and evaluate an industry-oriented education model in China, focusing on IT education, to help meet the vast demands of the Chinese software industry and foster stronger relations between the EU and China.

This paper explores the challenges and issues to the delivery of IT education identified from the results of the questionnaire for Ireland's emerging knowledge economy. Section 2 discusses the design and content of the questionnaire used. Section 3 presents details of the findings of the survey. The final section presents summary conclusions and offers some opinions on future of IT education.

2. Questionnaire Design

The primary purpose of the questionnaire was to ascertain the requirements of industry for graduates of a Bachelor (Honours) course in Computer Science as this area was highlighted in the Forfás Future Skills Needs analysis (Forfás 2003). The detailed aims were to identify the skills and other attributes that such a graduate should possess and their relative importance. In addition the questionnaire aimed to gain input from industry as to how these key skills could best be taught and assessed. The questionnaire was developed through a series of pre-tests including people with a combination of industrial and academic experience in the IT sector. The resultant questionnaire is a combination of a number of Likert statements with a request for supporting commentary to each response.

The questionnaire was administered using a modified version of the methodology outlined by Schaefer and Dillman (Schaefer 1998). The audience for the questionnaire was primarily organisations in a position to hire computing graduates. As this covers a wide spectrum, the questionnaire was designed to be sufficiently comprehensive to address the requirements of many diverse areas rather than focusing on requirements of a specific area. The questionnaire was also distributed to DIT academic staff to facilitate comparison of academic opinion with those of industry. Respondents were asked to identify technologies and techniques important in the current climate whilst keeping future requirements in mind.

The questionnaire was divided into eight sections, discussed in the following sub-sections. The introductory section asked the respondent to identify the positions for which they would consider hiring graduates from a Computer Science (CS) or Information Technology (IT) degree course. The final section provided space where respondents could identify issues not dealt with in other areas of the questionnaire.

2.1. General Areas

A number of high-level general areas are currently being delivered as part of third level CS/IT courses in Ireland. Respondents were asked to consider each of these and indicate, for their ideal graduate, or someone they would hire, the degree to which a graduate should have been exposed to that area during their third level education.

2.2 Technologies

The section on technologies was divided into eight sub-sections each covering a different area. Respondents were asked to categorise specific technologies they consider important. Technologies were chosen based on content of existing and past CS/IT courses delivered in Ireland.

2.3. Programming/Problem Solving

Since the current DIT BSc degree is heavily oriented to application development and programming in particular, a separate section on programming was included. This section gave a set of closed questions intended to extract from respondents what they consider to be the best method of delivery of programming skills.

An already recognised need in Ireland is the provision of creative and flexible graduates (Skilbeck 2003) rather than merely adept technical practitioners. Therefore problem solving ability in addition to programming skills are now essential for computing graduates. Respondents were asked to consider how they thought these two key complementary skills could best be taught in an industrially relevant manner.

2.4. Project Work

In keeping with the industrial ethos of DIT degrees, practical project work is highly emphasised on the current BSc degree. A section was included in the questionnaire to ascertain the types of project work that industry is most concerned with when hiring graduates. Questions dealt with the relative merits of team and individual work, the graduate's ability to ably document and communicate their results, the types of projects and the project goals in final year. This section addresses the issue of transferable skills, highlighted as an area of concern by the EU (2004) and the Forfás Expert Group on Future Skills Needs (Forfás 2003) and one that needs to be addressed urgently by education at all levels.

2.5 Assessment

Assessment is a key issue for all educational programmes and has long been a controversial issue. Respondents were asked to consider the relative importance of examination based and project-based practical assessment. In addition they were asked how influenced they were by the awarding body and level of a qualification and to consider the degree to which they are influenced by the grade of the graduate's award as opposed to the grade of the final year project.

2.6 Industrial Placement

Traditionally the industrial placement option was seen as the primary means of exposing students to industry practice. DIT's BSc degree in computing currently has an industrial placement in its third year (of four) with the intention to expose them to real practices and enhance their final year work on return. Respondents were asked to state how important they felt industrial placement was during a student's third level education. They were asked to state how much a student's overall grade should reflect their performance while on placement. They were also asked whom they considered should be responsible for grading this performance – academics or industrialists.

3. Questionnaire Results

The results were correlated and a numbers analyses completed. Responses of industrialists were compared with those of the academic staff to highlight any areas of difference. The qualitative findings of the questionnaire will be discussed in the following sub-sections highlighting the most important feedback and areas where industry responses differed significantly from academic responses.

3.1. Graduate Positions

Of those who responded from industry, the position for which they would consider hiring graduates included Software Developer, Business Analyst, Application Consultant, Java/Web Developers and Network Administrators. This indicates that there is a range of diverse opportunities for graduates of Irish computing degrees. Interestingly, positions ranged from the traditional starting role of developer requiring the usual technical skills to positions requiring more high-end analytical skills. When asked about initial training of graduates on starting employment, it was felt that a graduate should be able to begin contributing technically almost immediately, but would require some training on organisation specific operations or technologies.

3.2 General Areas

Most respondents felt that all areas of computing included were of high importance in an undergraduate computing degree. Academic respondents placed a higher emphasis on programming and networking than industry respondents, as these are traditionally considered to be core components of third level CS/IT courses. Mathematics was identified as being of lesser significance to industrial respondents, however academics understandably considered it important since it is essential to developing the key abstraction and decomposition skills required by the IT industry.

Given the increasing globalisation of the Irish economy, management, law and an awareness of the wider business areas in which IT is used were identified as being of importance. International languages however were not considered to be significant. In addition the following additional areas were identified as being important:

- Security,
- Business Processes,
- Professional Issues and Ethics, and
- Project Management.

3.3 Specific Technologies

Although respondents did specify certain technical skills as being very important, this varied according to the particular industrial area of the respondent. There was general agreement that graduates should be exposed to a range of technologies, and that the detail of specific technologies did not strongly influence the hiring of a graduate. The key technical skills identified for the current market were:

- Java
- C/C++/Visual C++
- Oracle
- Unix

Academic respondents placed a higher emphasis on the teaching of Java as a programming language since it is currently the main programming language employed in the advanced stages of all the CS/IT courses in the DIT.

3.4 Programming and Problem Solving

Almost complete agreement existed amongst respondents that programming,problem solving and algorithm design are complementary skills that cannot be taught in isolation. Industrial respondents did agree on how best these skills should be taught however all agreed that problem solving should be emphasised as a strategically significant skill for the computing graduate. Almost complete agreement also existed amongst respondents that several programming languages should be taught over the course of the degree to ensure that the student can demonstrate problem solving skills through programming rather expertise in a particular programming language.

3. 5 Project Work

Just over half of the respondents replied that there should be an equal divide of work produced independently to work produced in teams. Slightly more industry respondents favoured teamwork whereas academic respondents very slightly favoured individual work. This is obviously due the inherent difficulty in academically assessing individuals in group-based scenarios.

All respondents considered that a graduate’s ability to document and present their work highly important. Many respondents highlighted technical writing and presentation skills as being highly desirable amongst the skill-set of computing graduates.

Industry respondents placed a high emphasis on the importance of a graduate’s ability to gather information from contacts external to the organisation for purposes of completing project work. This indicates a requirement that graduate be able to demonstrate industry relevant practical skills in their project work.

The final year project is considered a highly important aspect of the majority of Irish computing degree programmes. Industry respondents considered that the main goal of the final year project was the understanding of the research domain of the project as opposed to academic respondents who chose obtaining scientific results as the main goal. Again this difference reflects the requirement of industry that the student undertake industrially relevant project work. It creates a difficulty for educational institutes which must also be aware of their dual role of equipping graduates to be able to work in industry and to evolve in the future by providing them with research and independent learning skills.

3.6 Assessment

Assessment continues to be a contentious issue, over half of all respondents said that 30% to 50% of assessment marks should be allocated for practical work as opposed to theoretical understanding assessed by examinations. When asked about assessing the final year project mark, the majority of respondents consider this mark to be equally important as the overall grade of the degree.

All respondents stated that the nature of the graduate’s academic award, for example a diploma or a degree, is highly influential to them. Industry respondents were not overly influenced by the awarding body but more by the grade of the award. Some academic respondents however considered the awarding body more significant.

3.7: Work Placement

The majority of respondents considered industrial placement to be of importance. Interesting the majority of respondents considered that some cognisance of the students work placement should be considered in graduate’s final award grade. However it is recognised that this is incredibly difficult to accurately assess a student’s performance on industrial placement but that it would be a key incentive to ensure student commitment to industrial placement.

3.8 Additional Comments

Respondents used this section to identify issues not dealt with in the main body of the questionnaire, to summarise their views of the desired nature of third level CS/IT course, and to comment on the quality of graduates they had previously hired and managed. The two central themes that emerged were as follows:

- the objective of a degree should be to provide the graduate with computing principles and fundamentals, leaving the specifics to the filled in by the employer,
- another objective of a degree should be to equip the graduate with skills to *learn how to learn*, rather than individual technologies.

4. Conclusions

The survey findings make interesting reading for IT educators in today’s economy especially when considered in conjunction with the changing environment in which graduates will be expected to work. Employers key requirements have not changed: they do not expect graduates to be immediately productive but do need graduates to be equipped with core competencies who will be able to become productive in a short time with training; they expect graduates to be equipped with the necessary skills to adapt to changing needs as appropriate and acquire new skills quickly.

Problem solving is considered a skill that should be given equal importance to the technologies used. This is to be expected given the nature of the IT industry where employers need their employees to able to apply their skills to a diverse range of problems. This needs to continue to be taught in a complementary manner to programming which is still considered an essential skill of computing graduates. Employers expect students to have significant practical experience on graduation. They do not give much importance, however, to the particular technologies studied rather they expect graduates to have experience using a range of technologies. This is encouraging since it is impossible for third level educational institutes to be consistently predict the technology skill-set required by a graduate at the end of a four year degree cycle. Rather they should constantly monitor trends in the IT industry to identify the most relevant skills and endeavour to ensure graduates are exposed to the most relevant technologies.

Employers place high emphasis on the need for graduates to have demonstrable practical ability. Employers expect graduates to have completed a significant amount of project work, both team and individual, at all stages of their degree. Significantly projects need to be tuned to reflect industry requirements. This highlights the need for closer co-operation between industry and educational institutes to identify suitable project work. The traditional mechanism of exposing students to industry practice through an industrial placement option is still considered important. However it should be combined with more industrially focused project work in all years of a degree.

Another key requirement identified is the need for graduates to be able to work in teams and individually. Employers rate key transferable skills such as presentation and communications skills highly, this reflects the findings of existing research into the requirements of education at third level in Ireland (Curry 2003). Industrial placement is an ideal way for these key transferable skills to be acquired in an industrially relevant manner, and must therefore be considered strongly in the development of any educational programme.

In summary employers continue to expect computing graduates to be competent in traditional areas. However, they do not place particular importance on the individual technologies used, taking the opinion that these skills can be acquired in the workplace. They rather are looking for graduates who are demonstrably capable of applying their skills to diverse problems and acquiring new skills as appropriate. Considered more important than the technologies to which graduates have been exposed, is their ability to *'learn how to learn'* which reflects the requirement of the EU (EU 2000). Indeed, this is one of the key objectives identified by EU education ministers in achieving the aims of the Lisbon strategy (EU 2004).

The IT industry in Ireland is faced with the challenge of adapting to meet the requirements of the global economy and in particular to become a leader in the proposed EU knowledge-based economy. Ireland needs to produce computing graduates who are thinking, reflective practitioners, i.e. who continually think and reflect about how they do their job, how this relates to latest research and theory and how this relates to their continuous professional development (Pring 1999). Irish third level educational institutes must therefore produce graduates who recognise the need for continuous self-learning and provide them with the skills to achieve this while continuing to equip with the technical skills they require.

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