

Computer Experience – Enhancing Engineering Education

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Abstract – Considerable attention has been focussed on identifying factors which predict student success on undergraduate engineering degree programs. One factor which has proved a valuable predictor in other fields is that of computer experience. This paper reports on the findings of a study which explores the computing experiences that undergraduate engineering students have prior to commencing their degree program. It aims to identify key facets of computer experience which can be used to improve and enhance undergraduate learning and thus contribute to student success.

Index Terms – Engineering, Computer Experience, Retention.

INTRODUCTION

Computing concepts are fundamental components of many engineering disciplines and it is imperative that undergraduate students acquire the essential computing skills and experiences needed to master these areas as quickly as possible. The difficulties encountered by students during the transition into university degree programs are manifold and are often cited as a major contributor to the non-completion of courses [1]. Moreover for those students who successfully complete their undergraduate studies, their learning experiences during the early years of the degree program have a significant influence on the final grade they obtain[2].

The engineering degree program offered by Trinity College Dublin is based on two years of general engineering education followed by two years of specialization in one of five separate areas: civil, structural and environmental engineering; mechanical and manufacturing engineering; computer engineering; electronic engineering; and electronic and computer engineering. The nature of the degree program offered at Trinity College, Dublin is such that for almost all students there is a high level of continuity between key subjects studied during the secondary education senior cycle and those encountered during the first year in University (e.g. Mathematics, Physics and Chemistry). However, some of the undergraduate core curriculum subjects studied (e.g. Computer Science and Graphics and Computer Aided Engineering) are beyond the scope of the students' previous experience. Students who encounter difficulties with these new disciplines during the early years of their studies find that

this has a negative impact on their academic performance throughout their undergraduate career [2].

Much effort has focused on understanding the determinants of student success on undergraduate engineering degree programs [3, 4]. One factor which has proved a valuable predictor in fields as diverse as the health sciences and business is that of computer experience [5, 6, 7]. However there is little agreement on a precise definition of this term [8] and most computer experience scales have yet to undergo rigorous cross validation or generalization beyond their initial target populations. Hence, in order to improve the quality of teaching and, therefore, the learning experience of undergraduate Engineering students, it is essential to understand the aspects and features of their prior computer experience that positively influence their performance. Such a detailed understanding of computer experience and its influence on student success should provide for the more effective deployment of computing resources to support student learning across the undergraduate curriculum.

The study described herein uses qualitative methods to explore the main computing experiences of undergraduate engineering students prior to commencing their degree program. It aims to identify key elements of computer experience which contribute to, and enhance, undergraduate learning. The data used to explore this theme was gathered from both undergraduate students and the faculty members who instruct and guide them.

In this paper we present details of the study and the chosen research methodologies. The results of the qualitative study are presented along with supporting excerpts from interviews. These are then assessed and analysed and recommendations made on how the computer experience construct can be redefined for undergraduate Engineering students.

COMPUTER EXPERIENCE

It is over two decades since researchers first began to study computer experience [9, 10], convinced of its impact on key criteria such as attitudes towards computers and subsequent computer-related behavior [11]. In many early studies computer experience was used to refer to the amount of computer use [12, 13] – however a growing body of research has adopted a wider view of the construct. For example, one of the more comprehensive definitions states that computer

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experience consists of four components: amount of computer use, opportunities to use computers, diversity of experience and sources of information (e.g. peers, media, teachers) [14]. Smith et al. [7] use these four components as a measure of *objective computer experience* (OCE) which they define as “the totality of externally observable, direct and/or indirect human-computer interactions which transpire across time.” They also define *subjective computer experience* (SCE) [15] as a “private psychological state reflecting the thoughts and feelings a person ascribes to some previous or existing computing event”. Smith et al. [7] argue that computer experience must be viewed as a bi-dimensional concept, whose components are both objective and subjective computer experience. In this work we focus on obtaining a measure of objective computer experience which captures the breath and depth of undergraduate Engineering students’ experience.

METHODOLOGY

The categories and characterizations provided are derived from the analysis of qualitative data gathered from freshman and sophomore engineering students, as well as from the academics involved in instructing them. Where interviews were conducted these were transcribed and analyzed following the grounded theory methodology [16].

Three target groups were chosen to participate in this study: first year undergraduate students who had completed the first semester of the engineering degree program, final year engineering students who were in their last semester before graduation and academic staff members who teach on the engineering degree program. Repeat students, transferring students and students who had previously been enrolled in a higher education course in the same or in another institution were not included in the first year group. Students on special programs and visiting students were also excluded from this grouping.

Each student participant was asked to describe their experience of taking the undergraduate engineering degree program, to give their view on the important computer experiences a student should have prior to commencing the degree program, and to describe common computer problems they encountered and their strategies for overcoming these.

Each faculty member was asked to describe their experience of teaching on the undergraduate engineering degree program, to give their view on important computer experiences that students should have prior to commencing the degree program, and to describe common student mistakes and misunderstandings in relation to computers and computer usage and the pedagogical strategies they adopted to address these issues.

Initially the analysis focused on a target group, rather than on individual contributions. This was to avoid becoming focused on the views of an individual participant, rather than on the synthesis of the ideas raised by the group as a whole. Firstly, conceptual descriptions were associated with the transcripts. These were then summarized in memos and linkages between conceptual descriptions were noted. Finally a series of categories was produced by sorting the memos

according to their content type. This analysis was repeated for each of the target groups.

THE FIRST YEAR STUDENTS’ PRIOR EXPERIENCE

The first year students’ perception of their prior computing experience is graphically depicted in Figure 1. This data was collected at the start of the first semester of the Junior Freshman (first) year. The students’ main experience is with Computer Games, Word Processing and the Internet. A recent study [17] which presents data on Transition Year (Grade 10 equivalent) students’ perceptions of their prior computing experience found that they had very little exposure to Computer Programming Languages and Computer Graphics. Despite this, over half of the first year Engineering students expressed themselves as being competent to very experienced in these areas.

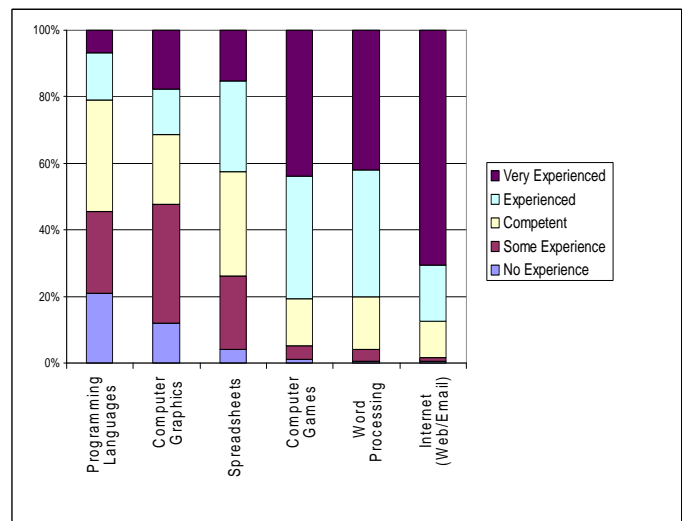


FIGURE 1
A SUMMARY OF THE FIRST YEAR STUDENTS’ PRIOR EXPERIENCE

Qualitative data revealed that the main use students made of the Internet was for social networking with others through e-mail, chat rooms and blogging. Where students used the Internet to assist them in their studies this was mainly for accessing a small number of specific sites to assist them with their assignments and continuous assessment tasks.

THE FIRST YEAR STUDENTS’ VIEW OF COMPUTER EXPERIENCE

The categories and characterizations below are derived from qualitative data collected at the end of the first semester. The key questions used to reveal the students’ conceptions of the computing experiences that contributed to success were: “What computing experiences had a positive influence on your performance during the first semester?” and “What computing experiences do you think are important for those wishing to succeed on this course?” Six distinct categories of experience were identified. These were:

- **Equipment:** The first category focused on the computer itself: students found that faculty members and tutorial assistants made incorrect assumptions about their knowledge of, and familiarity with, computer equipment. These ranged from being unable to operate specific pieces of equipment (e.g. dealing with printer problems such as paper jams and print cartridge replacement) to knowing which of the University’s computing facilities they were allowed to access. Alan expressed this as follows:
Alan: “..the computer, ... , learning to fix the small problems that you get... you have the basic knowledge, but they think you know more... you know, you may want to print something but you can’t get the printer to work, ...you know, little things like that”
- **Operating Systems:** Students who had experience of multiple operating systems felt that this was of great benefit to them. However, it should be noted that students who had experience of only one operating system did not feel that this had a limiting impact on their performance. Barbara commented on this:
Barbara:“...you need to know how to use different computers,...like, I know how to use a Mac and Windows, which is a real help.”
- **Software:** Many students stated that they were expected to master a number of complex computer applications in a very short period of time and that prior experience of these applications would have assisted them greatly. Colin is clearly frustrated by this:
Colin: “... Well, basically, you’ve got all these things [applications] they give you and then you’ve got to understand them so you can use them ... and there’s no time, you know...”. All are glad that they know how to use word processing applications and that this has assisted them greatly.
- **Programming:** All students identified prior programming experience as an essential skill:
David: “... if you knew Java, it’d be easy”
- **Networking:** Students found tasks such as setting up a wireless LAN card to access the University’s computing facilities difficult. Many also experienced problems accessing their user space on the University system as they were unable to access the appropriate network drive.
- **Internet Searching:** Students felt that being able to find relevant information on the Internet was an essential skill.

The computing experiences identified as important by the first year Engineering students are summarized in Table 1.

THE FINAL YEAR STUDENTS’ VIEW OF COMPUTER EXPERIENCE

The final year students who participated in the study were asked about computer experience during the last semester of their undergraduate career. The main questions used to capture their opinions were: “You had many computing experiences prior to commencing this degree program. Which of these do you believe have had a positive influence on your performance?” and “What computing experiences do you think are important for those wishing to succeed on this course?” Five distinct categories of experience were identified. These were:

- **Operating Systems:** Like the first year students, it was felt the more operating systems you are familiar with the better.
Alice: “..if you *really* know how to use windows, then it helps.... you can set things up, ... you can spend ages doing something, but if you know it already, you can do it quickly.”
Alice was not alone; in particular, almost all students wished they had more experience of resolving class path problems.
- **Software:** The final year students expressed similar views to the first year students in this area.
- **Installation:** This is closely related to the previous category. The final year students felt that knowing how to deal with problems that arise when installing software was an extremely useful skill.
Brian: “...take [names a class], I spent the weekend trying to get [software for a project] installed and found I had to install [another application] first...how was I to know?”
- **Programming:** The final year students felt that prior programming experience was a distinct advantage. Indeed, some student’s felt their lack of experience in this area had a negative impact on their performance from the start of their undergraduate career:
Claire:“..the others all knew how to program and I didn’t... I didn’t know who to ask. I still can’t do it, ...my final year project didn’t need me to do it, thank God.”
- **Networking:** Students felt those who knew some networking were able to get on with course work more quickly as they knew how to fix problems.
- **Internet Use:** Many students felt that they web searching skills they had acquired were invaluable. Donal expresses this in the following way:
Donal: “...if I knew where all the good websites were,... like, if I knew where to look.... The amount of time I spent looking was phenomenal, ...and now, I just know where they are.”

The computing experiences identified as significant by the final year Engineering students are summarized in Table 2.

TABLE 2

TABLE I
THE FIRST YEAR STUDENT’S VIEW OF COMPUTER EXPERIENCE

Category Label	Category Description
Equipment	Experience with specific equipment and facilities e.g. printers, laboratories
Operating System	Experience with using operating systems
Software	Experience of using new applications.
Programming	Includes both programming languages and programming environments.
Networking	Issues related to network access and setup.
Internet Searching	Where to find relevant resources and materials

THE FINAL YEAR STUDENT'S VIEW OF COMPUTER EXPERIENCE

Category Label	Category Description
Operating Systems	Experience with using operating systems e.g. Windows, Linux, OS X, Solaris
Software	Experience of using new applications.
Installation	Knowing how to install new drivers, applications etc and how to deal with installation problems
Programming	Includes both programming languages and programming environments.
Networking	Issues related to network access e.g. Mapping network drives and accessing wireless LANs.
Internet Use	Where to find relevant resources and materials

THE FACULTY MEMBER'S VIEW OF COMPUTER EXPERIENCE

In order to provide a balanced view of the concept of computer experience, faculty members were also included in this study. The key question that was used to illicit their conceptions of the key computer experiences needed by undergraduate students were: "In your opinion, what computing experiences would be of most benefit to an incoming first year student for their undergraduate career?" Most expressed very strong opinions and were quite forceful in their replies. The five categories identified are:

- **Report Preparation:** Faculty members felt that a large number of undergraduate students did not know how to prepare, structure and present a report. This included the correct use of fonts, providing appropriate section headings and the inclusion of citations. Andy: "Some students don't seem to know where the spell check button is"
- **Operating Systems:** The faculty members were divided on this issue: some felt that prior experience of a variety of operating systems was beneficial, while others felt this experience was not a prerequisite and could be gained in a University setting.
- **Programming:** Strong opinions were expressed on this matter. Some felt that prior programming experience would be beneficial, while others expressed concerns that students would acquire "bad habits". It was felt that those who had learnt procedural programming languages struggled to master and appreciate the object-oriented paradigm. A majority felt that some programming experience was better than none at all.
- **Networking:** Networking experience was viewed as a necessary part of modern life. One faculty member asserted that all school leavers should be able to set up a network connection and know how to protect their computer from external threats.
- **Internet Use:** The faculty members were certain that almost all undergraduate students were familiar with e-mail and the web. However, they expressed concern about how the Internet was used: Student attitudes to plagiarism

were mentioned by many and it was felt that student's did not know how to use the Internet correctly to enhance the quality of their learning. Most Faculty felt that incoming students could make better use of their time spent on the Internet.

TABLE 3
THE FACULTY VIEW OF COMPUTER EXPERIENCE

Category Label	Category Description
Report Preparation	Experience of word processing, spreadsheet and document preparation
Operating Systems	Experience with using operating systems e.g. Windows, Linux, OS X, Solaris
Programming	Includes both programming languages and programming environments.
Networking	Mapping network drives and access to wireless LANs.
Internet use	Plagiarism and the correct use of resources and materials.

The five categories identified as important in the Faculty Member's view of computer experience are given in Table 3.

DISCUSSION

There are strong links between the categories of description identified for each of the participant groups in this study. This is particularly evident for the first and final year student groups.

In almost all cases, the first year students' view of computer experience is split into two distinct classes: they are concerned with either the small, specific experiences that they feel would enhance their learning (e.g. knowing how to deal with printer problems, being able to access a network drive, the syntax of a programming language) or with much larger experiences (e.g. knowing how to use a number of different operating systems, knowing how to program). However, while these students are aware of their lack of experience in specific areas, they are unable to quantify this fully. The data collected also provided strong evidence that the faculty members and tutorial assistants were assuming a higher level of experience and application than was the case in reality. This was causing some students to become anxious and frustrated.

The final year students had a more mature view of the computing experiences they feel are beneficial; however they found it difficult to separate experiences that should be acquired prior to commencing the degree program from those one should acquire during the course of the degree program. They feel that all incoming students should know how to program, however they are unable to articulate why they feel this to important. While issues such as resolving class path difficulties hamper their progress, they are aware this is part of a wider gap in their experience.

Interestingly, the final year students do not feel that experience of word processing and spreadsheets enhanced their learning experience. They view these as generic skills, rather than computer experiences. The Faculty members take a different view: they feel that incoming students are unable to create properly formatted, structured reports.

The final year students and Faculty concurred that prior experience of computer programming was essential for incoming students – albeit that neither group could clearly articulate why.

Arising from our study the following have been identified as significant in the definition of computer experience for Engineering students:

- Efficient and Focused Internet Use
- Experience of Programming constructs and concepts
- Clear, concise and correct presentation of technical content in report form.
- Familiarity with typical application user interface modalities

CONCLUSION

It is clear that the categories currently used [7] to define objective computer experience are overly constrained and inappropriate for characterizing incoming Engineering students. Four factors have been consistently identified by all groups as substantive elements of computer experience for incoming undergraduate students. These factors capture both the generality and specificity of computer experience that participants felt most contributed to undergraduate success.

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