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A Bridge Over the Computer Science Graduate Skill Gap

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Abstract
Universities are increasingly required to respond to the ever evolving needs of an ever more sophisticated and globalised workplace, which requires well-rounded workers with more than mere technical knowledge. Employers expect their prospective employees to already have acquired a range of professional and personal skills. Universities face a challenge in helping students to develop these skills and it is debatable whether this can be achieved within the university environment. What is needed is a way for students to interact with the outside world as part of their undergraduate programme in a situated learning environment. This paper reports on a computer science assignment specifically designed to develop professional and personal as well as discipline-specific skills. The results suggest that situated learning assignments are indeed able to enhance the development of precisely those soft skills which are so valued by employers.

Keywords
graduate attributes, graduate skills, human-computer interaction, situated learning, critical social theory, teaching/learning strategies

INTRODUCTION
More school leavers are attending university than ever before, creating a situation where graduates skilled in particular knowledge areas outnumber the available jobs (Pybus & Smith, 1999). McKenzie *et al*. argue that graduates now need more than mere *disciplinary capabilities*. They also need to demonstrate *professional* and *personal* capabilities to compete for available jobs (McKenzie, Morgan, Cochrane, Watson, & Roberts, 2002)(see Figure 1).

Nair et al., refer to the need for *hard skills* (McKenzie's disciplinary capabilities), soft skills (McKenzie's professional and personal capabilities) and global skills (related to conducting business in a global world) (Nair, Patil, & Mertova, 2009).

Universities are increasingly aware of the need to nurture the development of non-disciplinary graduate skills (graduate attributes) (Bowden, Hart, King, Trigwell, & Watts, 2000) (Andrews & Higson, 2008) (Zepke & Leach, 2010).The problem for educators is that it is far easier to teach facts than it is to develop *skills*. The former

teaches students *what* to think, the latter teaches them *how* to think. Whereas one can easily create a realistic environment for the development of *hard* skills within the university environment, it is difficult to achieve this for the other skills. It seems inevitable that students should develop these skills in a *situated learning environment*, which is strongly associated with informal learning outside the classroom (Balolan, Zurita, & Milrad, 2011). This requires students to make contact with people and circumstances outside the rarefied atmosphere of the university environment (Gruba & Al-Mahmood, 2004). This paper considers how we set about nurturing a subset of these non-disciplinary graduate skills by using a situated learning approach.

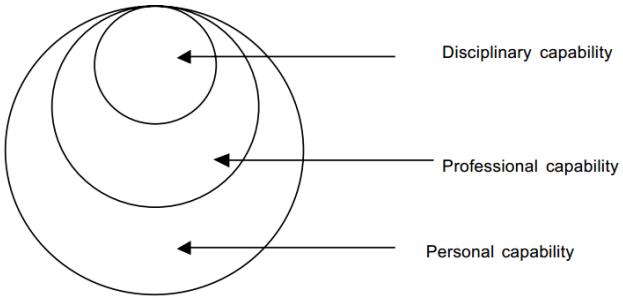

Figure 1: The nested domains of capability (McKenzie, Morgan, Cochrane, Watson, & Roberts, 2002, p. 432)

LITERATURE

Having decided to trial situated learning, the actual skills that should be addressed with an assignment had to be identified. Reviewed literature indicated that many researchers considered teamwork, communication skills (both oral and written), professionalism (including ethical behaviour), multiplism (the ability to cope with uncertainty) and the ability to do research, to be the most important graduate attributes for computer scientists in the workplace (Bowden, Hart, King, Trigwell, & Watts, 2000)(Andrews & Higson, 2008) (Zepke & Leach, 2010) (Crawford, Lang, Fink, Dalton, & Feilitz, 2011) (Aiken, Martin, & Paolillo, 1994) (Barrie, 2007) (South African Government, 2005) (Wong, 1995).

Teamwork is highly rated by industry. It develops oral communication skills encouraging students to accept responsibility, to plan, and teaches students how to behave professionally (Aiken et al., 1994). Burbules and Linn state that

> "… students must experience the activities and processes of the scientific enterprise in order to understand them fully, and that students will come to a better understanding of the methods of scientific investigation when they participate in these activities as part of a social group" (Burbules & Linn, 1991, p. 229).

Employers have identified poor written communication skills, in addition to a lack of work experience and unrealistic expectations (Raymond, McNabb, & Matthaei, 1993), as a deficiency in many graduates.

Professionalism in the workplace suggests specialised subject knowledge but also ethical behaviour such as honesty, integrity, time management and accountability. Ethics in social science argue for the following over-riding principles: *non-maleficence, beneficence, autonomy and justice*. Students thus have to understand the requirement to: *do no harm, respect their subjects and to try to do good* (Beauchamp, Faden, Wallace, & Walters, 1982) (Murphy & Dingwall, 2007).

Very few science-focused courses require students to accept other worldviews or to accommodate those who think differently from themselves. Perry refers to this *unthinking certainty* as a *dualist* level of development, where all issues are simplified to being either *black* or *white* (Perry, 1970). To move towards an awareness of mul-

tiple equally valid points of view (Perry's *multiplism*), students need to experience this in real life. Kloss argues for students to be given a nudge in this direction, by creating tasks and environments that will invite students to change their views. This will enable them to, for example, design interfaces for people who do not see the world as they do (Kloss, 1994).

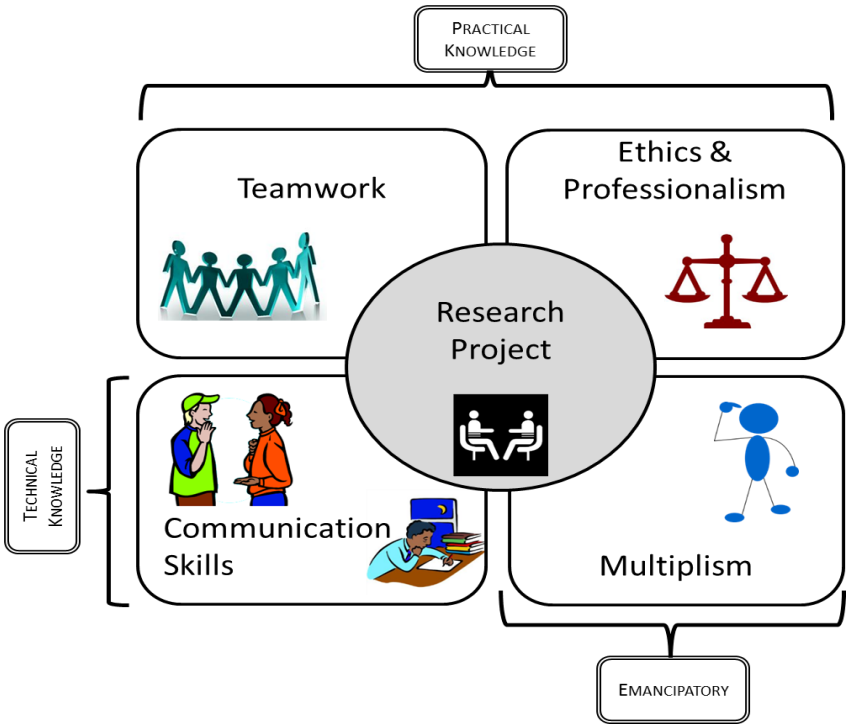

Figure 2: Targeted Skills

A situated learning oriented human-computer interaction (HCI) assignment was developed for a third-year university computer science course to nurture these targeted *soft* skills, but also to develop HCI subject knowledge and skills required by the educational institution (Association of Computing Machinery, 2008). This assignment addressed: teamwork, communication skills, professionalism, multiplism and the ability to do research (see Table 1 and Figure 2). These skills map naturally onto Habermas' three types of knowledge interests, which, according to him, drive all human inquiry: the *technical*-, *practical*-, and *emancipatory* knowledge interests (Habermas, 1974) (Habermas, 1972) align very well with this research project.

Table 1: Mapping the skills targeted by this assignment

Targeted Soft Skills	Habermas Category	Provision in the assignment
Teamwork	Practical	Self-formed teams had to collaborate in presenting their findings. Take a pro-active role in teaching a participant to use a particular function of their phone.
Verbal Communication skills	Technical	Ability to communicate with non-technical "customers" and people in a different generation.
Written Communication Skills	Technical	Ability to perceive, interpret and describe the HCI challenges faced by senior mobile phone users and whether they were able to incorporate results from published literature, into their jointly written reports.

Multiplism	Emancipatory	Promote goal orientation, motivation, self-awareness and seeing the world from a different perspective. Students were exposed to a different generation's experience of modern technology.
Professionalism	Practical	Working with older adults required them to be aware of the ethical issues related to interviewing people who would perhaps tire easily and be threatened by their own inabilities.
Ability to do research	All	Students were required to consult the research literature and to incorporate a summary of relevant literature into their report.

METHOD

Self-selected student teams were instructed to act as if a large mobile phone company, who would like to target the over-65s market, employed them. To determine the needs of this market, the company tasked them to conduct a research project to understand the older users' experiences with, and perceptions of, their mobile phones. For this research project each student had to interview two older mobile users, consult relevant research literature, and then combine their findings into a single coherent joint report. The team's over-arching task was to report their findings in such a way that *their company* would be able to gauge the potential and challenges associated with this niche market.

Since a team-size of between 3 and 6 has been found to be optimal (Jaques, 1995), the 2011 third-year computer science class (32 students) were instructed to group themselves into 7 teams of 4 to 5 members.

The teams were instructed to consult research papers that specifically addressed mobile phone usage by older users. They had to refer to these papers in their reports and include a list of the references they had consulted. Each team member had to identify two mobile phone owners who were at least 65 years of age, to explore their experiences of their mobile phones and to assist them with mobile phone functions they were not familiar with, but wished to use. The students interviewed their participants using a pre-designed questionnaire issued by the course lecturers. In their reports they had to comment on whether they were successful in teaching their participants how to use the unfamiliar function and to reflect on the time it took (the number of times they had to demonstrate the use of the function) before the function was understood. Finally, they were asked to consider the strategies they themselves (as younger mobile phone owners) make use of to learn, and those their older participants deployed (in contrast) to grasp new concepts.

For consistency, each student captured their participants' responses in a standardized excel spread sheet template provided by the lecturer. The team combined their data into a single sheet to facilitate some statistical analysis of their data for their combined report.

Each team report was e-mailed to the lecturer by a specified deadline and the lecturer evaluated these reports with a rubric. The rubric addressed four categories (the mark allocation for each category is given in brackets): appropriate research documents found, how well these were incorporated into their reports, as well as correctness of the referencing of these articles (20%); quality of completed and captured questionnaires (10%); discussion of the function(s) taught to the participants (50%); and recommendations for how the design of the interface of the mobile phone should be improved to better suit older users (20%).

PRESENTATION OF RESEARCH

A total of 32 third-year computer science student researchers took part in the study. The majority (90%) were aged between 20 and 29 years. The participants the students interviewed were an elderly family member (35%), an acquaintance (27%), a stranger (13%) or a friend (25%).

To determine whether the set coursework assignment had developed the targeted skills it was necessary to use a qualitative analysis technique to find such evidence in the teams' reports. Content analysis was used to analyse the eight team reports to find evidence of soft skill development (Travers, 1969 as cited in Cohen, Manion and Morrison, 2001, p. 164) (Corbin & Strauss, 2008). The reports revealed that the majority of teams functioned well, showing evidence of the development of teamwork skills such as leadership; responsibility and effective oral communication. Students learnt how to present their findings in a comprehensive report – thus developing their writing skills. In the field of HCI, students must be able to see things from perspectives other than their own. Evidence of multiplism was found in the reports: students reported a realisation that their subjects learned differently and that their physical constraints impacted their usage of the phones. Students had to act professionally by acknowledging the ethical aspects of their research. Evidence of this was found in their reports on how they approached their participants and the timeous completion of their tasks (see Table 2).

Table 2: Evidence for development of the targeted skills

Targeted Soft Skills	Evidence for Skill
Teamwork	All teams felt a "… sense of community with others involved in the scientific enterprise …" (Burbules & Linn, 1991, p. 239) and functioned satisfactorily, but one team reported that a team member left the team to join another team. The leadership and responsibility aspects of this project were mostly achieved through teamwork. Teamwork uses the strengths of each team member to achieve the outcome, thus developing various roles to function as a team.
Verbal communication skills	Five of the groups used repeated verbal instructions augmented with a demonstration to teach new functions. Only two groups also provided written instructions for future use.
Written communication skills	All teams submitted a comprehensive report written in reasonable English.
Multiplism	"The older people seem to be slow learners, not because they are dumb or anything. It is just that most of them are resistant to change, they are basically comfortable with what they know and they do not feel any need to learn new things" "Older adults are a diverse group and the diversity within older adults increases in physical, sensory, and cognitive areas." "We have realised that bad eyesight is one of the common reasons that make them to find it difficult to interact with the cell phones."
Professionalism	They were required to use consent forms and had to ensure that all work reported was their own and none was fabricated. Tasks were timeously submitted, which demonstrated that students were able to manage their time effectively and behave professionally by meeting deadlines.

Ability to do research	The research process seemed to have been mastered well. However, the ability to reference as well as the integration of the content of journal articles into the research reporting was still lacking. Two teams did not reference any articles. One team had only one relevant reference. The rest consulted relevant literature and referenced it appropriately in their reports. Many students find the synthesis of different concepts, challenging. The skill "… of synthesizing multiple sources of information" is mentioned by Burbules & Linn (1991, p. 238) as a skill that needs development for scientific problem solving.

Evidence of the teams' ability to do research was found in their team reports, which were evaluated in terms of:

- How successfully the team integrated the referenced literature into the report;
- The completion of questionnaires and capturing of data;
- Discussion of the process and results of the function taught;
- Comments and suggestions on how the phone software/design could be improved for the elderly based on the information gathered during their study.

When evaluating student reports it was found that most teams found it difficult to integrate and reference the relevant literature (see "Literature & introduction" in Figure 3). This graduate attribute therefore needs more attention and students need to be given more guidance on how to cite and reference. In general students reported well on the questionnaire and provided proof of their completed questionnaires, except for one group, Team 7, who failed to hand in the required documentation to substantiate their data (see "Questionnaire" in Figure 3). The reporting on the functions taught (see "Taught function" in Figure 3), as well as how the mobile phone should be adapted (see "HCI adaptation" in Figure 3), was reasonably well done.

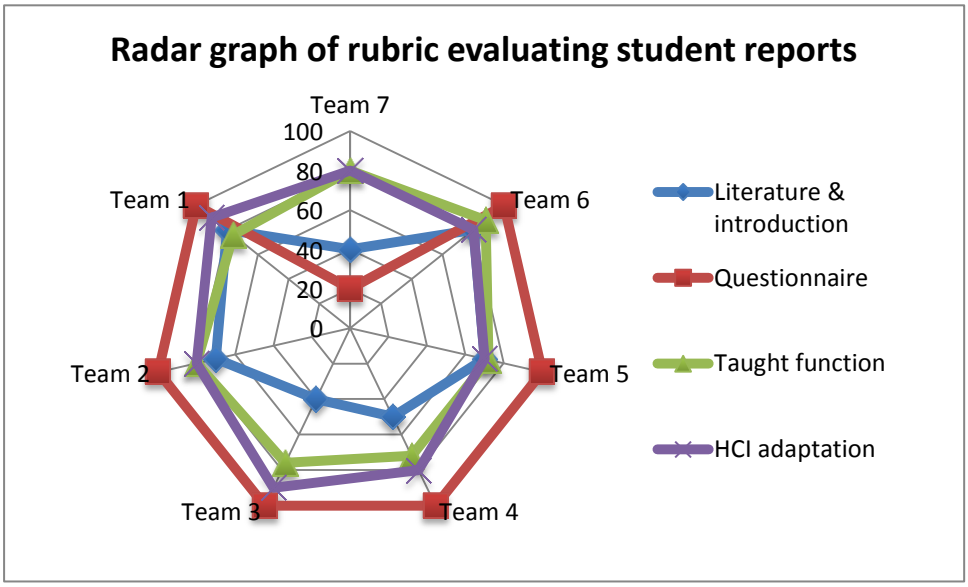

Figure 3: Rubric of lecturer's evaluation of research ability as revealed by the team reports

To interpret the results of the content analysis, critical social theory was used and Habermas' theory of critical social science and his three *knowledge interests* were applied (Habermas, 1972). Critical social theory's primary objective is the improvement of the human condition (Giddens, 1982). It takes into account the human construction of social forms of life. In his theory of critical social science Habermas op-

poses the claim that *science offers an objective or neutral account of reality* but feels that

> "… different kinds of knowledge are shaped by the particular human interests that they serve" (Carr & Kemmis, 1986, p. 134).

Technical Knowledge Interest

Comprehension and communication skills: ability to communicate with research participants and team members; comprehend and summarize articles; ability to write a report on work done.

Research skills: study research processes and techniques and apply correct procedures to indicate sources of material used; discern credibility and timeliness of resources; write a research report and adhere to a project plan to achieve the research goals; familiarity with research methods and be able to choose an appropriate methodology**.**

Table 3: The results of the study in terms of Habermas' Knowledge Interests (adapted from Ngwenyama, 1991, p. 270)

Knowledge interests	Graduate attributes	Knowledge products	Results
Technical	Communication skills Research skills	Scientific Knowledge Technology	Verbal and written communication skills were developed. Students had to acquaint themselves with various mobile technologies for demonstration purposes. Students were exposed to the research process of collecting, analysing and reporting on data.
Practical	Teamwork Professionalism	Social Consciousness Humanity	Acknowledged different generations, cultures and abilities. Learnt to have empathy with older mobile users and to acknowledge the legitimacy of their requirements. Learnt ethical practices such as getting permission from participants, adhering to deadlines and truthful referencing of other's work.
Emancipatory	Multiplism Responsibility	Norms for Justice Freedom	All team members had to take responsibility for their learning and timeously contributing to the team effort. In dealing with non-technical users they broadened their worldview. To share knowledge is in a sense emancipatory.

Practical Knowledge Interest

Teamwork: participate in team activities with an assigned schedule; schedule team activities with individual contributions to complete a combined task; assume different

roles within a team; collaborative team effort toward a significant problem, e.g. research project report; participate in a research culture: ability to provide resources to other members and be able to identify other members' skills and resources.

Ethics and professionalism: aware of and comply with ethical aspects of research such as not to plagiarise or fabricate results or references; adhering to deadlines; to do no harm; to respect their subjects and to try to do good.

Emancipatory Knowledge Interest

Multiplism: self-awareness and the realisation that there are different perspectives to their own, motivation and goal orientation to complete a task successfully.
Responsibility: taking responsibility for own learning; act as ambassadors to the community.

One of the aims of this study was to evaluate the effectiveness of a situated learning assignment to develop graduate attributes needed for the workplace. It was found, using Habermas' Knowledge Interests as a method of critique, that several graduate attributes were addressed and enhanced, namely: comprehension and communication skills; research skills; teamwork; professionalism; multiplism; and ability to do research. In terms of comprehension students demonstrated an understanding of the research problem and could interpret the results of their study satisfactorily (see **Table 3** and **Figure 2**).

DISCUSSION

The analysis suggests that this situated learning assignment allowed students to critically reflect on real-life situations. The student reports demonstrated an appreciation for the challenges that senior mobile phone users experience. The students suggested improvements to the design of these interfaces, indicating that they had engaged with the task and developed some of the targeted skills (oral and written communication, multiplism, and the ability to do research). Parker (2003) proposes a *transformational curriculum* which will

> "… inculcate a progressive cycle of engagement and critical reflection, of private and public, of problematising and trying out answers …" (Parker, 2003, p. 539).

Certainly this set coursework assignment encouraged reflection and the understanding of the difficulties experienced by senior mobile phone users enabling them to identify enhancements which could improve the experience of these users.

Team reports were analysed to demonstrate the extent to which the assignment developed the particular targeted soft skills. This produced evidence that this situated learning assignment did indeed help computer science students to develop some of the targeted graduate attributes.

CONCLUSION

At the beginning of this paper it was argued that the use of situated learning coursework could encourage the development and building of valuable *soft skills* in undergraduate students. This concept was trialled by sending students into the community to interview older mobile phone users about their use of, and difficulties with, their phones. The students worked in teams and wrote reports based on their experiences. Analysis of these reports showed evidence of clear benefit, both in terms of acquiring discipline-related HCI skills and in terms of developing *professional and personal skills*. The researchers are of the opinion that this approach demonstrates significant promise and is a realistic way for universities to expose students to those experiences which will help them to grow and develop and ultimately be more employable once they enter the job market.

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