Can Traditional HCI Principles Be Applied to Computing Technology in Learning Contexts?

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ABSTRACT
This paper presents an inter-disciplinary approach to studying computing technology in learning contexts. The approach was inspired by the difficulty in reconciling task and learning performance in the context of usability and instructional design. This is important because inter-governmental policy suggests computing technology may have a crucial role to play in supporting independent lifelong learning in informal contexts. The approach presented here is illustrated through an exploratory research project aimed at understanding the role of computing technology in the context of the Australian PhD candidature.

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Usability, task performance, learning performance

ACM Classification Keywords
H.5.0 General

BACKGROUND
There has been surprisingly little research into computing technology for learning within the human-computer interaction (HCI) community. This was first highlighted by the late David Squires in the 1999 issue of *Interacting with Computers*:

While there are now established traditions of research and development in educational computing and in human-computer interaction (HCI), workers in these areas rarely speak to each other or take note of each others' work: the educational computing literature is littered with naive and simplistic interpretations of interface design issues, and many writers in the HCI literature appear to be unaware of the significant developments that have been made in theories of learning. (Squires, 1999)

There is a perception in the more recent literature that 'traditional HCI principles and guidelines [often] need to be disregarded or broken in order to allow for the intended learning to take place' (Prates & Figueiredo, 2005). The need to do so suggest there is still insufficient understanding of computer-based learning applications by the educational computing and HCI community. The required dialogue can be construed in terms of Davies & Devlin's (2007) notion of disciplinarity. If the design of computer-based learning applications is to be seen as a cooperative effort involving multiple disciplines, then the ideal form of cooperation that Squires might refer to is coherent with 'inter-disciplinarity'. This form of disciplinarity describes two or more disciplines combining expertise to jointly address an area of common concern. What is distinct about this form of disciplinarity from other forms is that traditional disciplinary boundaries and contributions may be altered along the way. Contrast this with 'cross-disciplinarity'. This form of disciplinarity describes research into 'a topic normally outside a field of study … investigated with no cooperation from others in the area of study concerned'. It is a form of enquiry involving the use of 'essentially foreign techniques and tools from those normally used to study the phenomenon under consideration' and rarely involves any transfer of methodologies. Discourse in the educational computing literature (e.g., Ardito, et al., 2006) suggests current research and development efforts are still cross-disciplinary. Where learning technology in general is concerned, there is a need to problematise this approach. One of the reason is underscored by the limitation of the value that 'foreign techniques and tools' can bring.

The difficulty of achieving genuine inter-disciplinarity might be the result of radically different motivations and world views. Traditional HCI principles have generally placed emphasis on task performance. However, there is a strong indication that learning cannot be approached in the same way as task performance. As such, the application of usability principles to the context of educational computing is not always desirable.

Usability, in the straightforward sense, is a self-evident requirement for all software. Yet there is an interesting paradox in the case of some educational applications, where a seamless fluency of use is not necessarily conducive to deep learning. The learner needs to move effortlessly to the conceptual level, but then must engage with the underlying meaning. To put it simply, the software must make the learner think. Learning cannot be approached as a conventional task, as though it were just another kind of work, with a number of problems to be solved and various outputs to be produced. This is because learning is a by-product of doing something else.

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It is the 'something-else' that needs support. (Mayes & Fowler, 1999)

McDougall's (1999) account of the differences between an older and newer version of Microworld (a learning application) provides a practical illustration of this 'paradox'. In an older version of Microworld, the learner draws a circle by programming a 'turtle' to make an incremental series of forward and turning movements. In doing so, the learner 'encounters fundamental ideas underlying the concept of curvature'. Gronowski (1984) described this as an 'imperative' experiencing of the concept of a circle by the learner because of the effort required. This is an example of learning as a 'by-product' and the encounter as the 'something-else' needing support. In the newer but 'more usable' version of Microworld, a circle can be drawn easily using a circle drawing tool accessed from a drawing palette. In this scenario, Gronowski would describe it as a 'declarative' experiencing of the concept of a circle. Therefore, the learner only needed to recognise which of the tools had drawing properties that matched the descriptions of a circle. But once selected, the tool takes care of how the circle is drawn. McDougall argues that in this later version, the '[i]ssues of circle-ness, of how exactly a circle is made and defined, and of how one might achieve differences in curvature are not actually relevant … and are unlikely to be encountered'. In short, this version of Microworld is now more usable, but removes learning about circle-ness. This example illustrates a fundamental clash between the perspectives of HCI and education and the difficulty of achieving inter-disciplinarity.

INTERGOVERNMENTAL EDUCATION POLICY AS AN INSPIRATION FOR INTER-DISCIPLINARITY

The 'learning society' is an ideal described in the influential Delors Report (Delors, et al., 1996). It refers to a society that is 'founded on the acquisition, renewal and use of knowledge'. This ideal shifts the emphasis of education from teaching and teacher to learning and learner. It also transforms the concept of education from one of formal studies in an institutional setting to one of self-development and 'learning throughout life'. The notion of learning here refers specifically to acquiring knowledge, and is not synonymous with acquiring information. Knowledge is described as requiring 'effort, concentration, discipline and determination' (Delors, et al., 1996). This distinction is important because learning will now unlikely to take place for its own sake, but for the sake of generating novel knowledge. With the concept of education now implying self-development, there is a need to maintain a distinction between initial and continuing education. In doing so, it is also sensible to talk about learning contexts in terms of whether it is formal, non-formal or informal.

The Delors Report is commissioned by the United Nations Educational, Scientific and Cultural Organization expressly to 'study and reflect on the challenges facing education in the coming years and to formulate suggestions and recommendations'. It has been said to be 'the single most important educational document to have been published by UNESCO in the last quarter century' (Teasdale, 1999). Although the Delors Report was aimed to guide education policies at a national level, the ideas that were proposed are acknowledged to have transcended traditional notions of education and that they entailed broad socio-economic implications.

Another reason for problematising the cross-disciplinary approach to understanding learning technology in general is due to the need to be inclusive of other learning contexts. For us, the ideal of the 'learning society' provides both an inspiration and a means to think about learning technology and the issue of learning contexts prospectively. With the insights gained, we felt that we were no longer compelled to approach learning technology in terms of instructional and/or usability design. Most importantly, it drove us to think more specifically about the role of computing technology in a knowledge-based society.

With computing technology increasingly making data and facts more accessible, it was suggested by the Delors Report that this will have an important role to play in terms of supporting the learner in acquiring, selecting, arranging, managing and using information (Delors, et al., 1996). A further relevant report by the International Labour Organisation (2002) on learning and training for work in a knowledge-based society complements this suggestion. In addition, it implies computers may help the learner *use* information in terms of transforming information into knowledge.

The individual is becoming the architect and builder responsible for developing his/her own skills ... The relevance of knowledge about facts is diminishing, while the need to learn how to access, analyse and exploit information and transform it into new knowledge is increasing. It is only by giving the individual the desire, and tools, including financial means, to take charge of her/his own learning that he or she will be able to live and work in the knowledge and information society.

These two inter-governmental reports foreshadowed both the uniquely human demands of a learning society, and also the potentials of computing technology. They point to a need for inter-disciplinarity between HCI and education, but also the challenges it raises. One such challenge is: how do we study and understand computing technology in learning contexts that are not formal, and where the learner, not the designer, decides how computing technology will be used?

AN ILLUSTRATION OF OUR APPROACH THROUGH A STUDY DESIGN

We are currently conducting an exploratory research project aimed at understanding the role of computing technology in one small corner of education: the Australian PhD candidature. We chose this context because it exemplifies the context of informal learning and it involves learners who are motivated to generate novel knowledge.

Given the limitations of the 'design' approach, our first challenge was to find a coherent conceptual framework that did not require us to design something. In this case, self-regulated learning (SRL), as a broad conceptual framework, addressed our needs. While a distinct field of study within education, SRL brings a refreshing outlook to learning that breaks away from the traditional focus on teaching to instead focus on the learner. It distinctively approaches the issues of learning from the perspective of the learner and his/her strategic attempts at learning. It also provides an advantage over instructional design frameworks because it explains the role and value of computing technology in terms of the learner's agency. When evaluating instructional applications, what is often evaluated is the efficacy of the instructional design. This is suggested to be problematic from an augmented view of computing technology because if 'learners do not regulate their learning …, we may erroneously conclude that the [instructional application is] inherently ineffective, when in fact what is needed is to foster students' self-regulation when using these powerful but complex [instructional applications]' (Azevedo, 2005). As such, SRL influenced our decision to study computing technology and its roles in terms of how it is appropriated by Australian PhD candidates (henceforth candidates) to support their strategic attempts at learning.

With a broad but coherent conceptual framework to theoretically anchor subsequent exploration, our next task was to investigate how strategic candidates are and how computing technology was factored into their strategic learning practices. We adapted an online survey from Marzano's (1988) twenty-one core thinking skills framework. This was a practical, as opposed to a theoretical, framework in order to minimise loss of fidelity. The survey was aimed at finding out how often a specific thinking activity was reportedly carried out in the course of reviewing the literature, and how often it was reportedly supported by computing technology. Reviewing of the literature was selected as the scenario because it is the attribute common to all candidates. The survey received 103 completed responses. The sampling site was the University of Melbourne, Australia. Candidates were invited to take part in the survey through their faculty or department's research administrators in the form of an invitational email that we had provided. Research administrator were specifically instructed to disseminate the invitation only to PhD candidates (i.e., professional doctoral candidates were excluded) and if unable to do so, use the next best possible channel. The survey was administered online privately and its location was only disclosed to the candidates who were invited to take part. Through the findings of the study, we were able to ascertain that candidates do perceive themselves to use computing technology to support their strategic attempts at learning. However, this did not occur regularly. This finding is important because we were initially concerned that candidates may not use or perceive themselves to use computing technology to support their strategic attempts at learning. And when the data was broken down into disciplinary categories, we were also able to ascertain that the respondents' disciplinary memberships were generally not correlated with their strategic practices. While we did not uncover any interesting patterns or trends, the findings remained important as a basis for our progression to the next phase of the exploration.

We reviewed the literature further to understand the learning environment of the candidate, exploring topics such as learning demands and challenges, disciplinarity and academia as a community of scholarly practice. There was very little literature that was specifically situated in the context of the candidate. Nevertheless, we were inspired by the notion of how the candidate needed to demonstrate, through the literature review in his/her thesis, a coherent and substantive use of the literature (Holbrook, Bourke, Fairbairn, & Lovat, 2007). This subsequently influenced our decision to focus the research project on understanding the role of a computerised concept mapping tool. The decision was inspired by Novak & Gowin's (1984) theory of concept mapping, which is in turn, was inspired by Ausubel's theory of meaningful learning. Ausubel (2000, p. 1) asserts that learning requires 'both a meaningful learning set and the presentation of *potentially* meaningful material to the learner', meaningful learning occurs when the 'interaction between potentially new meanings and relevant ideas in the learner's cognitive structure gives rise to actual or psychological meanings'. He further argues that if one's 'cognitive structure is clear, stable and suitably organised, precise and unambiguous meanings emerge and tend to retain their dissociability strength or availability. If, on the other hand, cognitive structure is unstable, ambiguous, disorganised or chaotically organised, it tends to inhibit meaningful learning and retention' (Ausubel, 2000, p. 10). Novak & Gowin's basis for creating their concept mapping technique was that ideas that are novel, powerful and profound are very difficult to think about and consumes much time. As such, they are said to benefit from activities that mediate the process. With concept mapping, the interaction between potentially new meanings and relevant ideas in the candidate's cognitive structure is mediated by the controlled act of 'pushing and pulling of concepts, putting them together and separating them again' (Novak & Gowin, 1984, p. 19). Ausubel argues this leads to clarification and facilitates the emergence of precise and unambiguous meanings. As such, the need to demonstrate coherent and substantive use of the literature is dependent on having acquired a sound understanding of the literature. In this case, a computerised concept mapping tool may have a role in mediating the process.

Satisfied that there is potential for computing technology to support the candidate in understanding better the ideas in the literature, we embarked on a second focused study examining the role of a computerised concept mapping tool. We selected the Institute for Human and Machine Cognition's (IHMC) *CmapTools* for this purpose because it is free, has a negligible learning curve and its functionality is designed based on Novak and Gowin's concept mapping technique. This second study is longitudinal, involving four visits spread out over one year. The first visit was focused on exploring the immediate roles and consequences of CmapTools. The second, third and fourth visits was focused on exploring both the immediate and longer term roles and consequences.

In the first visit, participants were individually invited to the IDEA Lab located in the ICT Building at the University of Melbourne. This session was scheduled to last one and a half hours. It commenced with an initial briefing. This included an introduction to the nature of the study and the discipline the study was located in. This aimed to emphasise the HCI focus of the study. Following the briefing, each participant was asked to reflect on the conceptual structure of his/her research and to express it in free speech. This activity was limited to five minutes and audio recorded. After a short break, the participant was again asked to reflect on the conceptual structure of his/her research in writing. This activity was limited to fifteen minutes and screen recorded. After a short break, the participant was once again asked to reflect on the concept structure of his/her research, but now using on screen diagrammatic mapping with CmapTools. Prior to the start of the mapping activity, the participant was given an overview of the relevant features in CmapTools without being told or influenced to use any specific features or techniques. During the mapping process, the participant was also provided with technical assistance and advice whenever necessary. The process was also limited to fifteen minutes and screen recorded. Following this, a semi-structured interview was conducted with the participant.

The activities involved in the second, third and fourth visits were similar to the first visit. Participants were asked to reflect again on the conceptual structure of their research, but now only using mapping.

We are nearing the end of the study. Preliminary findings support the use of SRL as an overarching conceptual framework when investigating computing technology in a non-formal learning context. They also suggest this computerised concept mapping tool may fill a niche in the thinking strategies that are currently employed by candidates. However, we also found that candidates, despite their glowing appraisals of CmapTools, are finding it difficult to incorporate CmapTools as a part of their computing technology toolkit.

CONCLUSION

We began with the question: can traditional HCI principles be applied to computing technology in learning contexts? We suggest the problem is not one of application, but of amalgamation, as we previously argued using the notion of disciplinarity. We further highlighted how there are conceptual differences, in terms of task and learning performances, that limit the cross-disciplinary approach. Arbitrary application of traditional HCI principles to learning technology may offer temporary fix. But in order to understand computing technology in terms of how it is to support learning in the 'learning society', we need to step outside of traditional disciplinary perspectives and boundaries and embrace this as an inter-disciplinary enquiry. Our method illustrates one such approach that is based on the learner's agency. We have faith that our approach may allow for a coherent means of studying and understanding computing technology in learning contexts without having to arbitrarily reconcile task and learning performance.

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