THE ROLE OF METACOGNITIVE AND REFLECTIVE LEARNING PROCESSES IN DEVELOPING CAPABLE COMPUTER USERS

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Abstract

There is continued pressure for the application, and integration, of computer technologies into learning and teaching. For such innovations to be successfully implemented, students themselves must have the confidence, ability and willingness to engage with computer technology. In some disciplinary and professional contexts such as arts, humanities, social studies and education many adult learners are insecure and anxious regarding their ability to use, or to learn about, computer technology. Traditionally, competency-based, or skills-focussed training approaches have been utilised to assist inexperienced students to gain confidence with using computers. This paper argues that such approaches do not promote the development of individuals capable of life-long computer learning. What is lacking from such training contexts is a metacognitive dimension, which empowers learners to become more independent in their approach to learning with, and about, computers in the future. This paper discusses these issues and the potential role of metacognitive theory and reflective learning in re-conceptualising and re-designing computer end-user learning environments. Reference is made to a current research project, which is investigating the use of metacognitive and reflective learning approaches in developing capable computer users in one particular teacher education program.

Keywords

end-user computer education, metacognition, capability, reflection, 'expert learners', teacher education

Introduction

The annual conferences, and resultant proceedings, of the Australasian Society for Computers in Learning in Tertiary Education (ASCILITE) provide resounding evidence of the innovations being made in the application of computer technology in learning and teaching contexts. For such initiatives to be successful and well accepted, students undertaking study in these computer-mediated contexts need to be confident in their use of computers.

Surprisingly, little research or documentation exists that discusses the approaches which are taken to facilitate computer skills 'training', or the approaches which individuals take in their own learning. Even less literature documents the relationship between such 'training' or learning contexts and general computer confidence. Our experience would seem to suggest that in many organisational and tertiary contexts computer training programs are directive in nature, guiding participants through a series of step-by-step instructions. However, if one looks at the learning approaches adopted by experienced and confident computer users then it would seem that these individuals adopt quite different learning approaches compared to less experienced and less confident users. Firstly, most individuals who become adept at using computer technology learn experientially and, predominantly, through self-direction, rather than through short courses or training. If they do attend such training then they are unlikely to be concerned primarily with step-by-step instructions but rather with deriving broad conceptual understandings of the capacity and features of the software or hardware.

Information technology (IT) is developing at such a rapid rate that, if an individual undertakes training in how to use a particular piece of software, that knowledge is likely to be inadequate or out-of-date in a short period of time. This in itself presents significant challenges at the individual, organisational and social level. A relevant professional development program for IT requires more than skills training. It involves changes in attitude, values and beliefs (Lai, 1999, p. 16) that develop into the confidence for ongoing learning. Learning to use IT involves learning to adapt to change, to be flexible, intuitive and above all persistent! Learning through independent, hands-on experience and regular practice is vital and learners who know how to be self-directed and independent will be more successful than those dependent on structured guidelines (Ropp, 1998).

Directive teaching strategies that focus on providing directions to achieve certain specific outcomes (e.g. clicking on certain buttons) have their place. However, organisations and particularly higher education institutions also need to think strategically and sustainably about their teaching approaches, fostering self-directed and life-long learning. Such directive approaches may, in fact, fail to achieve long-term results if they reinforce dependency rather than independence. Organisations will increasingly feel the burden of ongoing training costs and will favour employees who are able to learn and adapt to new technologies without continual intensive training investment. Tertiary institutions will similarly receive pressure to foster such technological flexibility in their graduates.

How then can end-user learning and teaching environments assist individuals to develop life-long computer learning skills? In this paper one such approach will be explored. It involves a focus on reflection and metacognition (or metalearning). The paper will firstly provide a brief critique of competency-based approaches which have been widely adopted in IT contexts and contrast these to the notion of learning for 'capability'. A connection is drawn to the literature relating to metacognition and the 'expert learner'. The authors' current research is then discussed to illustrate how metacognitive learning approaches might be used to develop life-long capable computer users.

Computer Literacy and the Competency/ Capability Debate

The concept of computer literacy is an evolving one. Early literature emphasised the need for understanding hardware and programming (Higdon, 1995). At present the emphasis is application oriented, stressing skill development and competency in using particular programs (Oliver & Towers, 2000).

Competency-based training (CBT) approaches have been broadly implemented throughout the Australian Vocational Education and Training (VET) sector, and now compulsory education, sectors. Cornford (1997) suggests that this implementation has progressed with little rigorous evaluation or piloting and points to research highlighting its less than successful implementation. CBT emphasises pre-specified objectives and the achievement of clearly specified and measurable skill levels (Corben & Dunn, 1999). Competency-based assessment has been widely adopted in

schools and vocational education in the area of information technology and can be seen as underpinning a range of organisational and tertiary 'training' contexts.

The notion of competency can be contrasted with that of capability. Cairns (2000) defines capability as "an all-round human quality, an integration of knowledge, skills and personal qualities used effectively and appropriately in response to varied, familiar and unfamiliar circumstances." Cairns continues that capability implies "…having justified confidence in your ability to take appropriate and effective action to formulate and solve problems in both familiar and unfamiliar and changing settings". A now strong body of literature supports discussion of the value of capability approaches to learning (Australian Capability Network, 1996; Bawden, 2000; Cairns, 1996a, 1996b, 1997; Hase, Cairns & Malloch, 1998; Limerick & Cunningham, 1993; Price, 1996; Royal Society for the Encouragement of Arts Manufactures and Commerce, 1996; Stephenson, 1996).

Capability approaches gain greatest value in contexts of rapid change (Australian Capability Network, 1996). Working effectively with computers and IT require creativity, intuition, confidence in managing learning and in an ability to perform. It is these qualities which are seen as contributing to 'capability'. Adaptability to change and an emphasis on life-long learning are aspects seen as deficient in competency-based initiatives. Wildman (1996) states that competencies suggest a "reductionist philosophy that relates to specific measurable behaviours… measured against a set of standards". He goes on to state that "competencies tend to be prescriptive and are designed for a more stable environment with familiar problems." Stephenson (1993) emphasised the importance of capability (as opposed to competencies) to technological contexts, stating that:

> Any society in which progress and change are common features requires its people to be independently capable. The speed of technological, economic and social change means our jobs and circumstances change more frequently and less predictably than before. The explosion in the expansion of specialist knowledge (doubling every eight years by one estimate), puts a premium on giving people confidence in their own ability to learn and shows how futile it is to try to sustain the formal transmission of knowledge model … (p. 20-21)

These ideas all have relevance to the computer learning context, and support Loveless' (1995, p.xii) statement that computer capability is much more to do with an approach to learning and working than simply a set of technological skills.

Metacognition and the 'Expert Learner'

A connection can be drawn between the notion of 'capability' and that of the 'expert learner' as discussed by Ertmer and Newby (1996). By way of definition they state that expert learners "use the knowledge they have gained of themselves as learners, of task requirements, and of specific strategy use to deliberately select, control and monitor strategies needed to achieve desired learning goals" (Ertmer & Newby, 1996, p. 1). By way of further explanation they continue that:

> Expert learners notice when they are not learning and thus are likely to seek a strategic remedy when faced with learning difficulties… Novice learners, on the other hand, rarely reflect on their own performance and seldom evaluate or adjust their cognitive functioning to meet changing task demands or to correct unsuccessful performances (Ertmer & Newby, 1996, p. 6).

Expert learners are those who are aware of the knowledge and skills they do or do not possess and use appropriate strategies to actively implement or acquire them. They are thus self-directed and goal-oriented (Ertmer & Newby, 1996). Central to the notion of the 'expert learner' is metacognition. The term 'metacognition' appears to have emerged from the early work of Flavell who referred to it as knowledge concerning one's own cognitive processes and products or anything related to them (Flavell, 1976; Flavell, Miller & Miller, 1993). Biggs also discusses the role of metacognition in learning, utilising the term 'metalearning' to define the application of

metacognition to student learning (Biggs, 1985). More particularly, Biggs defines metalearning as students' awareness of their learning and control over their strategy selection and deployment (Biggs, 1985, p. 192). The metalearner is one who is aware of their motives, task demands and personal cognitive resources and exert control over strategies used (Biggs, 1988, p. 127).

Ertmer and Newby (1996) claim that metacognition facilitates the strategic performance of expert learners and that reflection provides the critical link between knowledge and control of the learning process.

> As a powerful link between thought and action, reflection can supply information about outcomes and the effectiveness of selected strategies, thus making it possible for a learner to gain strategy knowledge from specific learning activities… Whereas metacognitive knowledge might be regarded as the 'static' knowledge one has accumulated regarding task, self and strategy variables… reflection is believed to be a more active process of exploring and discovering… (Ertmer & Newby, 1996, p. 14).

In their exploration of reflection, Ertmer and Newby extended Schön's (1983, 1987) notions of reflection *on* action and reflection *in* action to include reflection *for* action. Reflection *on* action is defined as the active process of making sense of past experiences for the purpose of orienting oneself for current and/or future thought and action. Reflection *in* action is managing the process of learning and constantly adjusting and changing as new information is assimilated. However, reflection *for* action is "… employing reflective thinking skills to evaluate the results of one's own learning efforts" (Ertmer & Newby, 1996, p. 18).

In contexts of rapid change, such as in computer contexts, expert or 'capable' learners' metacognitive strategies provide distinct advantages, and may in fact be more important than skills themselves; "When asked to deal with novel situations, the specific cognitive skills and learning strategies we have available become more critical than the limited content knowledge we may possess" (Ertmer & Newby, 1996, p. 7). Thus, teaching approaches which can assist students to become 'expert learners' are more likely to empower them for life-long learning in turbulent and rapidly changing contexts, such as those involving computer technology. It is thus proposed here that metacognitive teaching approaches might foster greater long term learning capability for computer end-user.

Computers and Teacher Education

Teachers have experienced increasing expectations to incorporate computer technology into their teaching (Russell & Bradley, 1997). They are expected to have a broad range of skills in a wide range of software and adapt these skills to a diverse set of classroom situations. Additional pressure stems from expectations that teachers model positive, self-efficacious attitudes to their students (Delcourt & Kinzie, 1993; Russell & Bradley, 1997). For many teachers the gap between perceived technological competence and learning to use computers in their teaching is often threatening and overwhelming (Ropp, 1998). Many have high computer anxiety and low computer self-efficacy, which is further exacerbated by the often strong computer skills of *some* of their students. Furthermore, given the isolated and independent nature of their work, if they encounter difficulties there is often very little assistance or support available (Becker, 1994).

Teachers thus need to develop adaptive computer skills, including an ability to learn from colleagues, support personnel and students (Rea, Hoger & Rooney, 1999) as well as a capacity to engage in self-directed and experiential learning.

The Research Context

In 1999 the principal author became involved with teaching a Unit designed to provide pre-service teacher education students with information technology skills. This Unit is a core in both the Bachelor of Education (Primary) and Diploma of Education (Secondary) degrees. The student base included a wide range of people, many without strong IT backgrounds or any significant interest in computing. Some students had rarely used a computer at all, while others were quite experienced.

As future teachers themselves it was critical that these students developed the ability to engage with new and emerging software and hardware in creative and imaginative ways. While there were certainly some core skills that might be considered essential for this group, these future teachers needed to be prepared for a changing and unknown future technological context.

This Unit and its student group thus provided an excellent opportunity to investigate ways of assisting individuals to develop sustainable and life-long learning approaches toward computers – in other words an opportunity for investigating methods of developing 'capable' computer users.

The remainder of this paper provides a background to, and results from, an action research project that is investigating the use of metacognitive teaching strategies in developing more 'capable' computer users.

The Research Approach: Challenging Learners through Metacognitive Reflection

Action research was seen as an appropriate methodology given its focus on change processes, participation and reflection. This paper focuses specifically on the second research cycle of the principal authors' research conducted in Semester 2, 2000 with a group of 179 students from the Bachelor of Education (Primary) and Diploma of Education (Secondary) degrees at Southern Cross University.

The Unit was designed within a reflective learning context and encompassed a wide range of learning and teaching opportunities, encouraging students to engage with, and reflect upon, different learning strategies. Students were required to keep a journal throughout the semester over which the Unit was delivered which documented their reflections. This journal data, with the permission of the students, informed the wider research project and shaped further refinement of the teaching approaches for the next intake of students.

The Unit is presented as a flexible learning resource incorporating a fully self-contained online learning resource supplemented with optional tutorials. A major component of the Unit is a "Thinking" Module where students are presented with a body of theory and literature surrounding computer use and are encouraged to reflect on their own cognitive approaches to computers and their past and present learning processes. The Unit introduces students to the notion of computer 'capability' and students are prompted to reflect on individuals who they would consider to be 'capable' and in particular what learning strategies these individuals employ. Other specific theories encompassed include social-cognitive theory (self-efficacy), attribution theory, Kolb's learning styles and the notion of 'play'. Social-cognitive and attribution theories were also presented through a self-assessment survey. Based on existing survey instruments this survey was used not simply to gather data from the students but to prompt their own reflection on the influences on their learning. Students completed this survey at the beginning of the semester and then used their responses to the survey as a source of reflection while learning more about the theories. Students were again asked to complete the survey at the completion of the Unit so that they might observe changes in their own self-efficacy and attribution, and so that pre- and post-semester data might be analysed.

Students were provided with maximum flexibility in terms of the learning approaches they could pursue and were encouraged to 'experiment' with a range of learning approaches. For instance, a different teaching approach was employed in each of the tutorial sessions and students were prompted to reflect on these approaches in terms of short and long term learning outcomes. Teaching approaches included observation (data projection), verbal directions, exploratory learning (play) and cognitive modelling. Additionally, students are encouraged to pursue individual and small group approaches in working with the self-directed learning resources.

It is beyond the scope of this paper to detail the full findings of the research thus far. Instead, one particular aspect of the data is explored: the reflections of students on the notion of the 'capable' computer user. This aspect is illustrative of the potential of metacognitive learning and teaching approaches in fostering computer capability. The final section of the paper identifies the perceived limitations of the approach and the consequent focus of subsequent action research cycles.

Identifying Capability and Appropriate Learning Strategies for Capability

Students were prompted to reflect on someone who they considered to be a 'proficient' or 'capable' computer user and then to consider what learning approaches these individuals employed. The intension here was that students would have the opportunity of identifying a role model for their learning and, through directed reflection as to the learning techniques employed by such individuals, realise that they too could adopt such strategies.

Student responses, as represented in the reflective journals, were analysed and themes were identified from the data using a Grounded Theory approach (Charmaz, 2000; Glaser & Strauss, 1967).

There was a surprising degree of consistency across the responses from students with a core set of characteristics being identified. These core characteristics can be summarised as follows:

- confident in their own skills and abilities;
- patient and persistent, determined and calm;
- risk taker, courage to experiment, try new things, not afraid to make mistakes;
- methodical/ logical thinker;
- enthusiastic and motivated, enjoy using computers, positive attitude, personal interest;
- technical knowledge;
- love of learning;
- constant use, deep immersion; and
- problem-solving abilities, deduction.

When asked to reflect on how these capable computer users learn students almost always cited such approaches as self-directed learning, experimentation, trial and error, exploring and 'playing around'.

Notably, all the identified core characteristics, with the exception of the sixth, are metacognitive constructs. The notion of 'technical knowledge', which might be considered as a self-evident characteristic of a capable computer user, was considered by many students as secondary to the more general traits which were viewed as leading to a *capacity* to develop technical knowledge.

It was evident from the data that a dichotomy existed between student responses. One portion of students were focussing on the 'technical infallibility' of the capable computer user. Another distinct group saw the capable computer user not as 'all knowing' in terms of technological skill, but rather able to employ appropriate learning approaches. Indicative of this second view was the following comment by one student who stated that "When I think of a good computer user I don't necessarily think of an expert. I think of someone who can quickly work through problematic situations even though they may not readily have the required skills". Students adopting a purely skills-based technological focus were in the minority.

The Potential Impact of the Metacognitive Approach

The potential of the metacognitive approach is best illustrated through the comments of students who came to the realisation that 'technical ability' was not, in itself, the central issue in computer use. One student, for instance, noted that "people's attitudes towards technology is their biggest enemy, rather than their lack of natural ability" and another stated that "confidence is the key. I believe anyone that has confidence in their ability can use computers effectively".

Many students took the opportunity to reflect on their own learning processes in relation to those of their identified model, as is illustrated in the following quote:

> My brother is truly amazing. For myself, if something doesn't work I might try it again once but the majority of the time I will just 'give up'. My brother sees these 'failures' as challenges to be met and conquered. He delights in the fact that he never has to stop learning because there will always be a new challenge to conquer. He loves the fact the information technology is such a dynamic field that it is always changing, improving and making new breakthroughs.

Through such reflection quite a number were able to pinpoint weaknesses in their own learning. For instance, one student identified their own lack of willingness or procrastination in learning as contrasting with their model's approach of learning "by doing". Another commented that "If something goes wrong when I am using the computer I freak out and panic, but when I see these people use the computer they seem to be able to work it out on their own. It is obvious to me that I learn differently to them when it comes to information technology".

Many students went on to challenge their own learning approaches and in the process developed greater confidence and independence. This is illustrated in the following student quote:

> I think the best way to tackle concepts and skills on the computer is definitely a trial and error process and to go from what you know and then delve into the unknown. The attitude you should take is one of curiosity and dive in and have a go. This is how most people I think solve problems they encounter on the computer, although a little knowledge in each area is a help but overall the willingness to have a go. Then to improve in each area is to actually take the time and play on the computer and the program you are actually working with. Throughout these nine weeks I think this is the most valuable aspect of computers I have actually learnt – have a go and you will learn things that you would never had known if someone had taught you.

Another student stated that "… developing an attitude towards computers that doesn't place too much importance about how skilful you are in their use has lead me to the position I'm in now that I don't feel pressured or anxious".

Most refreshing, however, was the capacity of many students to translate their own experiences and reflections into espoused values for teaching their own future students. This is illustrated in the following student's writing: "...as a result of this reflection, I can see not only the type of IT user I would like to become, but also the IT users I would like to create within my primary school classrooms". In this respect the metacognitive strategy can be seen as impacting not only on the adult learners involved but future young people potentially affected by the resultant strategies employed by these teacher education students.

While the process of reflective journaling seemed to provide a catalyst for insight and personal change for many students, there were a significant number of students who did not seem to benefit as much from the learning and teaching strategy.

For some students the metacognitive learning context raised internal awareness but did not necessarily lead to transformation. Such students may, for instance, have noted that capable computer users tended to adopt self-directed approaches to learning (including experimentation,

trial and error, exploration and play) yet continued to indicate that they preferred, or sought, highly directive teaching contexts. For such students it seemed that an early insight had been gained however they were not developmentally ready to pursue such strategies themselves.

A greater limitation of the approach lay with individual students' capacity for reflection. Some journals simply did not evidence a level of reflection that provided students with an opening for transformation. This is not necessarily to say that these students did not experience reflective insights, but that their journals did not reflect this, either because of their lack of motivation and/or effort to write, or because of their lack of experience or capacity for reflective writing. For instance, students who indicated that the characteristics of a 'good' computer user were (solely) technical ability (as cited above) tended to be those who did not demonstrate a deep level of reflection throughout their journals.

A principle determinant, then, of the benefits of a metacognitive approach to computer end-user teaching and learning would appear to be the level and depth of reflective engagement by students.

Continuing the Research: The Search for Further Improvement

Further cycles of the action research project will refine these teaching approaches and explore methods to promote a greater depth of reflection and metacognitive engagement by students. Specifically, reflective small group discussion is being trialed as an alternative to written journal responses and a greater focus is being placed on self-analysis of motivation and goal setting.

Conclusion

Concepts of capability (as opposed to competency) and the construct of the 'expert learner' provide an innovative foundation for end-user computer education. Reflection and metacognition is central to the development of 'expert learners' and thus can potentially be seen to provide a sound framework for the development of 'capable' computer users.

The value of metacognitive approaches to end-user computer education is supported by the early findings of this research. In reflecting on their past and current learning approaches, and comparing themselves to a 'capable' computer role model students are more likely to challenge themselves to adopt learning approaches which are applicable for life-long learning. The factor which limits the success of this metacognitive approach most is the individual's capacity and motivation for reflection. Further research is aiming to refine the approach and determine if metacognitive teaching approaches can provide empowerment to a greater proportion of individuals.

This research has wider implications for tertiary education contexts, organisations and professional bodies. It suggests that careful consideration needs to be given to the type of computer 'training' being offered, particularly to individuals who might be considered to lack computer self-efficacy and who will need to continue to use computers in their profession and/or future careers. Competency-based and directive approaches may produce sound short-term outcomes, in the longer term may reinforce dependency of individuals on ongoing training. Metacognitively-based learning contexts may, however, represent a better long-term investment.

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