

2007

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Publication details

Post-print of Phelps, R 2007, 'The metacognitive approach to computer education: making explicit the learning journey', *AACE Journal*(International Forum on Information Technology in Education), vol. 15, no. 1, pp. 3-21.
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Phelps, R. (2007). The metacognitive approach to computer education: Making explicit the learning journey, *AACE Journal*, 15(1), 3-21.

The Metacognitive Approach to Computer Education: Making Explicit the Learning Journey

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This article presents a theoretical and practical exploration of a metacognitive approach to computer education, developed through a three-year action research project. It is argued that the approach contrasts significantly with often-employed directive and competency-based approaches to computer education and is more appropriate in addressing the longer-term learning needs of professionals such as teachers. The metacognitive approach focuses on beliefs, attitudes, learning strategies, and assists learners to come to terms with the nature of technological change and their own ability to confront this change by embracing life-long computer learning. In this article, the metacognitive approach is presented through a three-dimensional diagram. An exploration is also provided as to how the approach was developed and refined, through the research, into a print-based, self-paced learning resource, which forms one component of a flexibly-delivered computer education course. It is argued that the metaphor of “journey” might profitably be employed to support teachers in understanding the unique and individual interplay of metacognitive factors in their approach to using computers.

For future generations to maximise their capacity to operate within competitive and technologically driven economies, it is critical to foster computer abilities at every level of the schooling process, and teachers are central to this endeavour. There are great expectations for teachers to incorporate computer technology into their teaching and model positive attitudes toward computers to their students. However, information and communications technology (ICT) remains “one of the most significant challenges now confronting teacher education, teachers and schools” (Ramsey, 2000, p. 68). Many existing teachers, as well as a significant number of beginning teachers, have missed out on computer education throughout their schooling and have neither the skills nor confidence to effectively integrate ICT in their teaching practice. Furthermore, any initial training or courses they have received are unlikely to adequately prepare them for the wide range of technologies found in schools, the rapid rate of technological change and the many “technical problems” they will inevitably encounter.

Employing bodies, such as the Department of Education in New South Wales (NSW), Australia, have responded to these issues by mandating various computer competencies for new employees and requiring teacher-education courses to meet these competencies. Most schools and employers have also introduced training regimes to meet the immediate skill needs of existing staff. Such approaches are indicative of wider trends toward competency-based approaches to computer education; those that focus on “individual and measurable skills demonstrated and assessed against agreed standards of competence” (Cairns, 2000, p. 2).

This article argues that skills-based or competency-based approaches to computer education inadequately prepare teachers for a career of continued technological change. Technology is too diverse and evolves too rapidly for teachers to be reliant on workshops and seminars (Kirschner & Wopereis, 2003; Melczarek, 2000). Computer learning cannot be so oversimplified, but rather, involves changes in attitudes, values, and beliefs that develop confidence for ongoing learning. It involves learning to adapt to change, to be flexible, intuitive, and above all persistent. In short, it requires the fostering of teachers who know how to be self-directed and independent in their computer learning, rather than those dependent on structured routines or guidelines. Furthermore, approaches to computer education, which are competency-based and highly directive contrast significantly to the ways in which many computer proficient individuals learn, namely through self-directed exploration (Davis, 1999). Melczarek, for instance, emphasized the

importance of self-directed computer learning and recognised this as the naturalistic learning approach of proficient computer users:

Reliance on direct instruction will only lead to greater dependence on others and the need to continuously take technology courses and workshops... Only through self-directed learning will learners become dependent on themselves to solve their own problems, become life-long users and inherently learners of technology... This will hopefully lead to greater and more innovation in the use of technology... the future success of technology integration must be seen as being dependent on teachers developing their own ideas instead of simply implementing the ideas of others. (pp. 4-5)

This article describes a three-year action research project, which sought to develop an approach to computer education that would foster computer capability, rather than just competency. Capability is defined as “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” (Cairns, 2000, p. 2). The research methodology is outlined and the processes and findings that led to the development of the metacognitive approach are briefly explored. The resultant three-dimensional representation of the metacognitive approach to computer education is then presented and the article draws on reflective data from students, which illustrates the potential impact of the metacognitive approach on students. The aim is to provide a theoretical and practical overview of the approach. The article concludes by highlighting the potential of metaphor in presenting and communicating the approach to teachers.

THE RESEARCH CONTEXT

Southern Cross University, NSW Australia has, like most teacher education institutions in Australia, had a core course (the term “unit” is used in Australia) in ICT in its primary and secondary education programs since 1998. It is this course that is the focus of this article. To provide some brief context, the course is currently offered both internally (on campus) and externally (off campus) and exists as a fully online resource, enabling students to study independently, in their own time and at their own pace. Optional tutorials are provided for internal students and personal one-on-one

support is available to external students. Topics covered include the World Wide Web (WWW or Web), synchronous and asynchronous communications, multimedia, presentation software, file transferring, and web publishing, and their use and integration in the classroom, as well as pedagogical considerations concerning ICT, Internet-based educational activities, educational software, and ethical, legal, and classroom management issues.

When the author was appointed responsible for development and delivery of the course in 1999, pedagogical and practical limitations were perceived in what had been a very content-based, competency-focused approach (for instance, a major form of assessment was a final exam). Driven by a belief in the importance of capability in rapidly changing computer contexts, the author initiated a three-year action research project aimed at working with students to develop an approach to computer learning, which would foster future teachers' ability to use ICT in an ever-changing technical environment.

Action research was deemed to be an appropriate methodology to pursue both change (action) and understanding (research) (Dick, 2000). With a strong theoretical and practical connection to educational research and teacher professional development (Carr & Kemmis, 1990) action research focuses on practitioners making sense of, and improving, their practices (Hughes, Denley, & Whitehead, 1998). Action research is participatory, "directed towards and directed by those who are actually taking the journey" (Grundy, 1995, p. 9). As such, it provided an opportunity to elicit a greater understanding of students' experiences of computer learning and a valid approach to course redevelopment. The research consisted of three distinct research cycles, each involving phases of planning, acting, observing, and reflecting, and each progressing the understanding of the learning experiences of students. A total of 656 students were involved in shaping and directing the research over the three years. Data were collected in each cycle using multi-method approaches including survey instruments, observations, and qualitative data drawn from reflective journals maintained by students over each teaching period. Based on this feedback and learning, the course was iteratively modified and redesigned and a metacognitive approach to computer education of preservice teachers was developed (Phelps, 2002; Phelps & Ellis, 2002a; 2002b; Phelps, Ellis, & Hase, 2001).

HOW AND WHY WAS THE METACOGNITIVE APPROACH DEVELOPED?

In the first cycle of the research, survey and reflective data were collected from students to document their experiences throughout the course and their reflections on their past, present, and future approaches to computer learning. Aside from a number of functional issues (such as timetabling, workload, technical access, etc.) many of the themes that emerged from this cycle concerned more fundamental learning issues such as:

- the value of learning independence;
- motivation through realisation of professional value;
- confronting fear and dealing with difficulties and problems;
- memory and retention;
- knowing what is possible; and
- the personal benefits in achievement of self-set, ambitious goals.

The first cycle of the research clearly indicated that for many students, feelings, attitudes, beliefs, motivations, and learning strategies presented significant challenges and obstacles to their learning. Reflecting on, and challenging these factors, however, held considerable potential to invoke change.

The greatest opinion I have changed this semester is that computers are fun and interesting and not as scary as I had previously thought. From now on when I get a spare moment I will get on the computer and fiddle and hopefully that will help me learn more (Student 53, cycle 1).

Driven by a desire to empower students to embrace ongoing and lifelong ICT learning beyond the period of the course, the writer drew on the findings from the first cycle to develop and refine an approach to computer education which embraced metacognitive considerations.

“Metacognition” refers to knowledge concerning one’s own cognitive processes, and the active monitoring and regulation of these processes in the pursuit of goals (Flavell, 1976; Flavell, Miller, & Miller, 1993). It involves both self-appraisal (reflection about what you know and how you think) and cognitive self-management (the ability to plan and implement appropriate strategies and to monitor, adjust, and “trouble shoot” performance; Jones & Idol, 1990; Paris & Winograd, 1990). The benefits of metacognitive teaching approaches lie in their ability to transfer responsibility for monitoring learning from teachers to learners and in promoting positive self-perceptions, affect, and motivation (Paris & Winograd). Metacognition is a key element of learner self regulation, where students activate and sustain thoughts, behaviours, and affects, which support the attainment of their goals (Schunk & Zimmerman, 1994). Reflection is key to this development of “expert learners” (Ertmer & Newby, 1996). To summarise, metacognitive approaches entail supporting students to be aware of the knowledge and skills they do or do not possess, and to use appropriate strategies to actively implement or acquire them. In contexts of rapid change and unfamiliar content domains, such as are inevitable with technology, this understanding of “how” to learn provides distinct advantages (Ropp, 1997, 1998). It is these distinctions and definitions that underpin the differentiation of competency and capability. While a small number of writers have highlighted the value of reflection in computer learning contexts (Fokias, 1999) the explicit employment of metacognitive processes does not appear to have been previously discussed in the literature.

Through the second and third cycles of the action research a range of elements were identified as impacting on students’ computer learning and reflection on these elements by both the teacher/research and the students themselves became an explicit part of the learning process. Through the cycles, various elements such as learning styles, attribution, help-seeking, problem solving, and so on were developed into reflective prompts and metacognitive scaffolds, which were then tested with students. Those that proved most relevant and valuable in evoking insight and change in learning approach were retained. The resulting metacognitive approach incorporated a range of elements used as prompts for learning. These elements are presented in this article through both a three-dimensional representation of the underpinnings of the approach and a summarized description of the practical learning resource which students were able to work through at their own pace. These are presented in turn in the following sections.

REPRESENTING THE METACOGNITIVE APPROACH

The metacognitive learning process can be considered as addressing three major influences on computer learning: affects, strategies, and motivation. These three influences are acknowledged as impacting on individuals' past, present, and future computer use and learning. Figure 1 presents the metacognitive learning process through a three-dimensional visual representation of these influences and also provides a cross-sectional view of the model from above in order to represent the various elements of the metacognitive process. The various "layers" of the model are unpacked in the explanation following the figure.

The three dimensional insert to the figure depicts the metacognitive learning process as entailing an examination of past and present computer learning experiences with a view toward enhancing future computer learning. Within that broad framework, the model illustrates the interplay between an individual's affects (feelings, attitudes, beliefs and assumptions), motivations and adopted learning strategies, derived from their past and present computer use. The metacognitive process entails individuals actively considering the influence of these various factors through a process of planning, acting, observing, and reflecting.

When viewed from above the three-dimensional figure depicts the various elements that were found in the research to impact on individuals' computer learning and which proved to be valuable prompts for reflection. Here again we see the three influences; affects, motivation, and strategies at the three apexes. Positioned along the sides of the triangle are the *elements* that are incorporated into the metacognitive approach. These are located along the continuums between the three triangle apexes, as most logically representing their relationship to affects, motivation, and/or strategy. Thus, self-efficacy, anxiety, attribution, and learned helplessness are affective in nature, but self-efficacy and anxiety have more to do with motivation than strategies, while attribution and learned helplessness are more closely aligned with strategy use than motivation. Within this framework lies the foundational cyclic process inherent in action, and experiential learning: plan, act, observe, and reflect. It is this "cog" that drives the learning process forward, as students are prompted to reflect on their learning, plan, and act on improved strategies and continue to revise their progress as learners. All sides of the triadic model are interdependent and cannot be considered in isolation from each other. The "glue" that binds the elements together is *reflection* and this underpins the whole metacognitive learning approach.

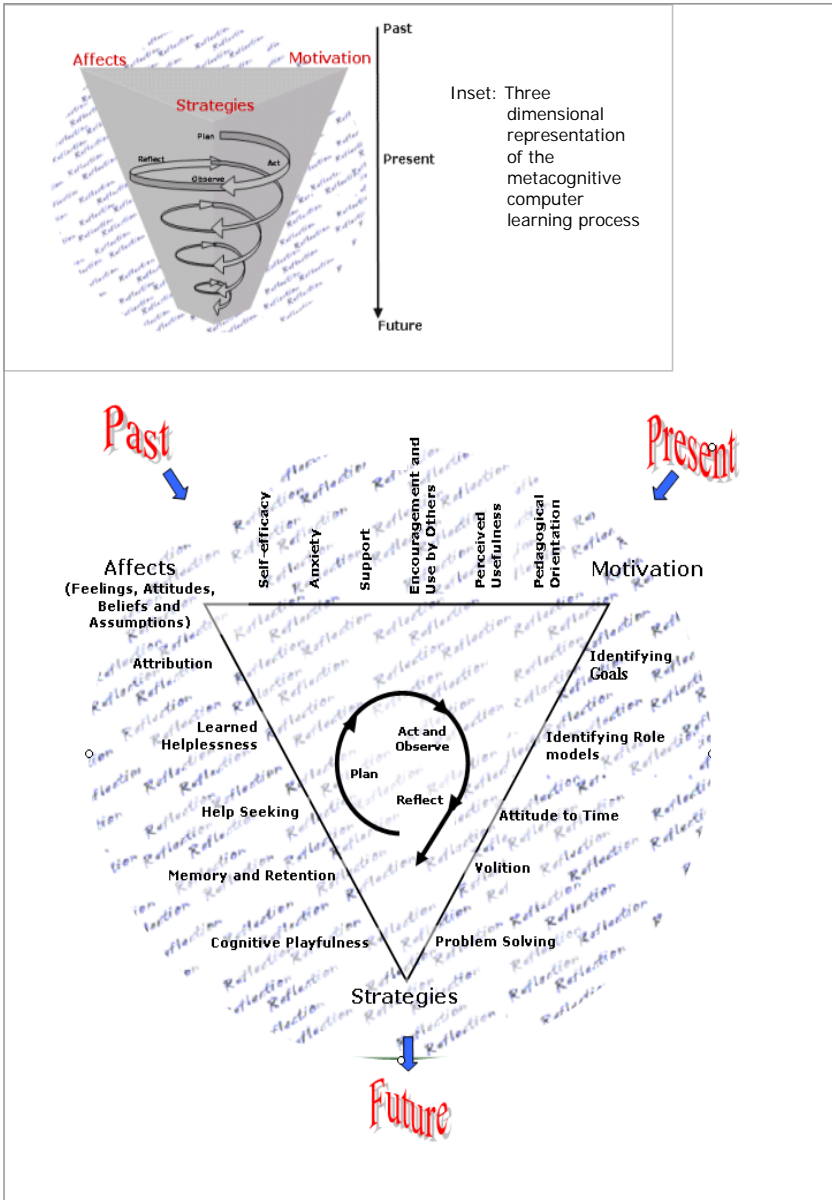


Figure 1. Visual representation of the metacognitive computer learning process

SCAFFOLDING THE APPROACH IN PRINT

In order to understand the practical application of the metacognitive approach, a description of the resultant course itself might be valuable. To scaffold students into the metacognitive process a print-based “Thinking” module was developed. This module involves participants (either individually, in pairs or in small groups) in identifying and reflecting on their initial feelings, motivations, and beliefs and the appropriateness of various learning strategies in achieving their own self-identified learning goals. This module forms the foundation for continued “reflection in action” as students engage with a range of unit resources and practical activities and continue to reflect on what influences their learning. Assessment was in the form of a learning journal (more recently varied to a learning portfolio), both of which maintain a strong focus on metacognitive reflection.

The Thinking module begins by introducing the metacognitive approach and prompting students to identify their initial feelings, motivations, and beliefs about the Unit, including hurdles they foresee. A brief statement emphasises that teachers are not expected to become computer “experts” but that their confidence and willingness to continue to learn is of most importance to their students. The remainder of the module is presented in three subsections.

The first section, “feelings, attitudes, and beliefs,” prompts students to reflect upon six metacognitive elements: encouragement by others, use by others, support, perceived usefulness, attitudes, and feelings/anxiety. Through a series of survey-type questions students self-identify their own level of computer self-efficacy and reflect on what has impacted on this in the past. The pros and cons of internal and external attribution (Henry & Campbell, 1995) are alluded to and learners are prompted to reflect on “appropriate attribution” (Phelps & Ellis, 2002c). Motivational issues are then considered and participants are asked to identify any educational or social concerns they have regarding technology.

The second section of the Thinking module concerns learning strategies. Students reflect on the strengths and weaknesses of various “pathways to learning” including group instruction, individual instruction, peer-group learning and self-directed learning, and the practicalities of these approaches for their continued professional development. The importance of lifelong learning is discussed and students consider their confidence to learn new

computer skills in contexts of dependency and independence. In an approach paralleling that of Akar and Yalcinalp (2000) and as advocated by Derry (1990), students are asked to think of someone they perceived to be a proficient computer user (a role model), to consider their characteristics, how they learn, and how this might influence their own learning strategies. This leads to an overview of the theory of playfulness (Martocchio & Webster, 1992) and students are encouraged to consider strategies for exploratory learning. The role of memory, note taking, and terminology in computer learning are also considered. The inevitability of “problems” and the importance of balancing problem solving and help seeking are explored. Mention is made of the importance of difficulty and effort in enhancing learning retention (Bjork, 1994), tied to notions of volition.

The third section of the Thinking module focuses on identifying and achieving learning goals. Students consider both their “big picture” goals, as well as sub-goals and a computer goal-setting chart is included to support them to do this. While this goal chart emulates a competency-based approach, within this context it acts as a metacognitive tool. There is no expectation that students achieve all listed skills but rather they are encouraged to be personally ambitious. Students are also encouraged to reflect upon their priorities and use of time. Finally, a section prepares students to move on to the other three modules in the course, prompting them to consider the nature of learning online and, in particular, the authenticity of the nonlinear learning environment (Phelps, 2003). They are also encouraged to confront their (potential) expectations that teachers should “tell you exactly what you have to learn, and how you should learn it,” an issue which emerged in the research as a primary impact on the students’ adaptation to the metacognitive approach. In this way it is emphasised that there is no single body of information in the Unit that all students *have* to work through identically, since everyone has different interests, existing knowledge and skills, and therefore different needs. The Thinking module concludes with an emphasis on students having fun.

The “Using” module (which covers more practical skills-based learning and the integration of these technologies in the classroom) is presented using five “windows” into each of the topics: Facts, Skills, Activities, Use in Schools and Reflection. These windows are accompanied by a bright, inviting and “fun” graphic interface, one which encapsulates an approach of “play.”

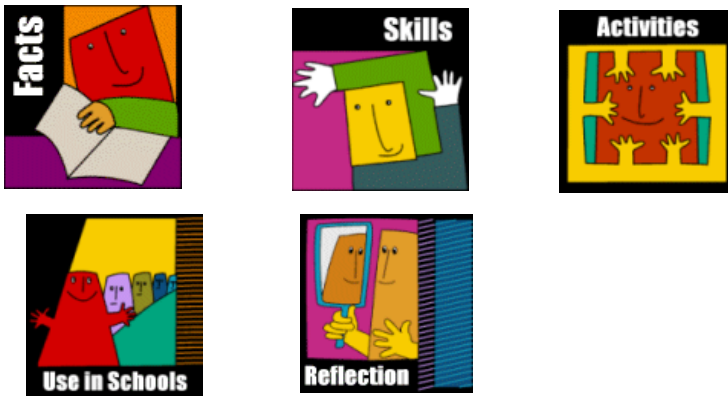


Figure 2. The five window structure to the using module

These five windows were developed as a result of insights from the research, which indicated the divergent needs and learning preferences of students; some students require foundational understandings (*facts*), and/or foundational *skills*, while others needed to be challenged to set and achieve more ambitious learning goals and to “test out” their knowledge through *activities*. The structure embodies a recognition of the importance of perceived usefulness (*classroom application*) and maintains the emphasis on *reflection*. This format thus emphasises students driving their own process of learning and continuing to reflect metacognitively.

THE IMPACT OF THE APPROACH

The metacognitive approach, as theoretically represented in Figure 1, and practically implemented through the Thinking module just described, has been utilised with successive cohorts of students at the undergraduate level (Phelps, 2002; Phelps & Ellis, 2002a; 2003) and more recently as professional development for practicing teachers (Phelps, Graham, & Kerr, 2004). It has been found to be highly beneficial to many computer users, particularly those most anxious about ICT. The comments of students themselves, however, speak most strongly about the benefits of the approach; “I think

that I have learned more about the way I learn than I have about the computer, which I think will be a more beneficial way of learning to be flexible with the changing nature of IT” (Student 109, cycle 2). Of even greater significance is the potential for the approach to touch the lives of the young people in these future teachers’ classrooms, as the following student reflections indicate:

I think that by creating a caring environment that believes “mistakes are our friends” and encouraging students to enjoy their own learning and to take some responsibility for their own learning I can foster the development of higher self-efficacy among my students and in turn influence performance positively. (Student 15, cycle 2)

From my reading this semester I know that there is a massive push towards empowering all students to be self-directed learners... I feel that learners need to know how to own their own learning, but that this does not come automatically, and teachers themselves need a lot of help in altering how they teach to achieve this aim. That is, if teachers like me *teach how they were taught* then this aim will not be realised. However for me, Units such as this one are influencing my philosophy of teaching markedly, and I know that already my teaching will be different than it would have been if I had... not done this Unit. (Student 28, cycle 2)

The approach thus helps individuals come to terms with the nature of technological change and their own abilities to confront this change. It fosters self-directed and lifelong computer learning and supports learners to adapt to change, to be flexible, intuitive, and above all persistent. Such an approach actively involves these future teachers in identifying what they need to learn and embracing the learning required. Of implicit importance is a focus on learning strategies and empowering learners to continue to learn computer skills throughout life. “Learners who have never been encouraged to take responsibility for their own learning can remain unaware of the power they possess as learners” (Hiemstra, 1994, p. 89). The resultant teaching approach thus sends a clear message that teachers need to develop adaptive computer learning skills, self-efficacious approaches to ICT, an ability to learn from colleagues, support personnel and students and to learn through independent hands-on experience and regular practice (Coffin & MacIntyre, 1999; Melczarek, 2000; Rea, Hoger, & Rooney, 1999; Ropp, 1998).

ONGOING DEVELOPMENTS: THE POTENTIAL OF METAPHOR

As is the nature of action research, learning has continued beyond the completion of the three-year project. Ongoing reflection on the approach has highlighted further possibilities for development. Various writers have explored the use of metaphor and its integral connection to our construction of meaning (Hovelynck, 1998; Lakoff & Johnson, 1980; Mignot, 2000; Ortony, 1979; Taylor, 1984). Metaphor permeates communication and perception, not only at individual, but at cultural and societal levels (Mignot). It can encourage us to develop new forms of understanding and can challenge our very conceptual systems and learning approaches. In this section the potential of metaphor is explored as a fresh and yet untested way of applying the metacognitive approach to computer education.

Throughout the three-year research the metaphor of “journey” recurrently arose in the words of students, and tutors alike in both depicting the metacognitive learning approach and supporting learners to embrace the process of becoming capable computer users. In “playing” with the appropriateness of this metaphor in supporting computer learning a second representation of the metacognitive process was developed (Figure 3). Although, as yet, this model is untested as a scaffold for learners, it is proposed that the metaphor might be usefully conveyed in Figure 3.

This representation acknowledges that any traveller carries with them *luggage*; the feelings, attitudes, beliefs and assumptions, which influence how they interpret their travelling experiences. If this luggage is heavy and inflexible it can slow the traveller down and impact on their interpretations of the journey. If the traveller is prepared to reassess their luggage along the way, casting off inappropriate “possessions” and replacing them with more appropriate artefacts, the journey will be enhanced. The traveller also needs to know the broad *itinerary* for their journal and the reasons why they are going in a particular direction. Without the motivation and conviction that the journey is worthwhile they are unlikely to get far. The traveller also needs some means of *navigation*: a map to guide their travels. Of course, they may start out with a large-scale map to provide broad direction, but as they progress they will need to refine their map and look more closely at the strategies required to facilitate their journey. Sometimes the most exciting travelling adventures will start from no real concept of destination beyond adventure itself. What is important is that the traveller develops the conviction and confidence that the journey is worthwhile and achievable. The same might be said of computer learning, where the best learning adventures are seen as having no end or final point.

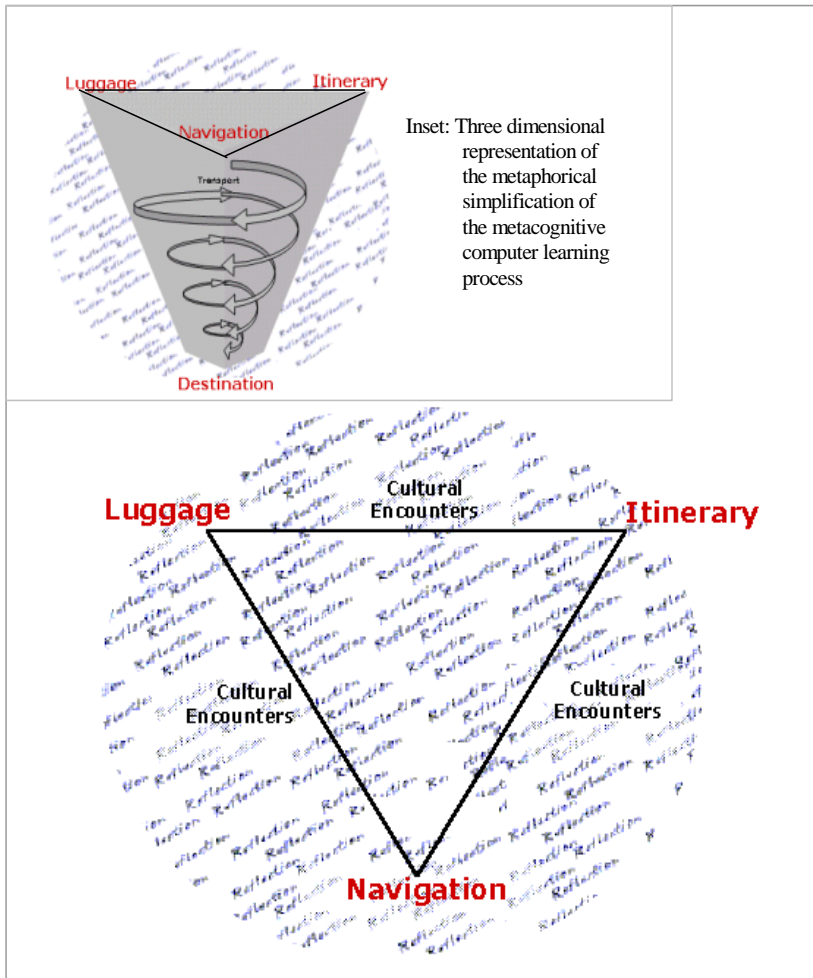


Figure 3. Metaphorical simplification of the metacognitive computer learning process

Within this triadic framework is some consideration of the means of *transport*: the way of progressing through the adventure. The implication here is that all steps along the journey need planning, acting, and evaluating, and if one form of transport is ineffective, or one route inaccessible, then another should be chosen. Through reflection on our experiences we learn

which approaches are better than others in certain circumstances. So too, in the computer domain, we need to develop understandings of which learning strategies are best employed in each context. The metaphor might be continued, with each element (as identified in Figure 1) being representative of a cultural encounter; an experience gained along the way, which teaches us something about ourselves and our journey. Finally, what we gain is a combination of the photos and the memories of our experiences which combine, through reflection, to teach us something about our present situation. These reflections also provide the impetus and excitement to continue our travelling adventure in the future: to become lifelong, capable computer learners.

The original diagrammatic representation of the metacognitive approach and this latter one, founded on the use of metaphor, are currently informing and being utilised explicitly in another action research initiative investigating the application of the metacognitive approach in supporting whole-school change in the use of ICT by practicing teachers (current research 2004-2007).

CONCLUSION

The metacognitive approach to computer education, which has been detailed from both a theoretical and practical perspective in this article, has significant potential for empowering both future teachers and practicing teachers. It moves beyond the short-term quick-fix approaches inherent in competency-based models and provides a mechanism for building capability for lifelong learning and adaptation to the rapid rate of technological change. These things are vital if teachers are to be prepared for tomorrow's technological possibilities and challenges; not just those of yesterday and today. It is hoped that the descriptions and models provided in this article will encourage teacher educators and those involved in teacher professional development to reflect on whether they are fostering computer *competency* or computer *capability*. Above all, the article challenges all educators to embrace the lifelong learning journey that *is* computer learning, and to make it an explicit part of their teaching.

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