New Learning: Re-apprenticing the learner

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Abstracts
The preparation of graduates who are able to use theoretical knowledge to become independent, critical thinkers ready for the workforce and career and life changes is a major problem facing academics in higher education. This paper explores the theoretical background to the development of The Interdisciplinary Critical Thinking Tool (TICTT), a dynamic Internet tool based on an eclectic educative model that incorporates concepts from cognitive apprenticeship, problem-based learning and critical thinking. Through the use of these concepts, the tool’s design re-apprentices the learner to develop contextual knowledge and compare this knowledge to expert ways of knowing.

La nouvelle Education: un nouvel apprentissage de l’apprenant
La préparation d’étudiants diplômés qui peuvent utiliser des connaissances théoriques pour devenir des penseurs critiques prêts pour faire face des changements de la force de travail, de la carrière et de la vie est un problème majeur auquel doivent faire face les enseignants de l’enseignement supérieur. Cet article explore l’arrière plan du Interdisciplinary Critical Thinking Tool (TICTT), un outil dynamique d’internet fondé sur un cléctique d’éducation qui incorpore divers concepts depuis l’apprentissage cognitif jusqu’l’enseignement quivible sur des problèmes et la pensé critique. Grâceà l’emploi de ces concepts le structure de cet outil constitue un nouvel apprentissage pour l’apprenant faisant appel un savoir conceptuel et compare ce savoir des méthodes de savoir développés par des experts.

Neues Lernen: Zu Fragen des Wieder-in-die-Lehre-Gehens von Absolventen
Im Bereich der akademischen Bildung ist es ein größeres Problem, Absolventen darauf vorzubereiten, Ihre Fähigkeiten im Umgang mit theoretischem Wissen zu nutzen, um auch im eigenen Berufs- und Privatleben unabhängige, Kreative Denker zu werden. Dieses Papier beschreibt den theoretischen Hintergrund zur Entwicklung eines bereichsüberschreitenden dynamischen und kritischen Internet-Denk-Werkzeugs (TICTT), das auf einem eklektischen erzieherischen Modell basiert, das Konzepte kognitiver Lehre, problemorienten Lernens und kritischen Denkens integriert. Durch die Verwendung dieser Konzepte wird es möglich, dieses Werkzeug so zu gestalten, dass die Studenten wieder lernen, kontextuelles Wissen zu entwickeln und dieses Wissen mit auf fachlichem Weg erworbenem zu vergleichen.

Introduction
The aim of every university degree programme is to provide graduates with a comprehensive education enabling them to apply and transfer their knowledge and skills to a range of work orientated situations. As consumers of education, students are now requesting greater flexibility of design, preparation in the use of information services and technology and a desire to graduate prepared to function in a changing work environment. However, the transition to the workplace has not always been viewed as smooth (Somerville et al., 2000). Graduates often relate this to a perceived inadequacy of their course to prepare them for the reality shock they encounter. Educators are being challenged to develop courses that integrate teaching and learning theories with technology based instructional design.

The need for a generic tool able to support critical thinking across a range of highly discipline specific contexts required a shift away from dedicated courseware with static html pages towards the development of more dynamic software. Two general approaches were adopted. First, dynamic Internet tools are essentially frameworks overlaying a database in which content is primarily generated by course participants. The database
includes case information, teacher questions and accumulated participant responses and discussion and, over time, becomes a resource that may be edited and re-presented in different ways for subsequent course participants. The capacity of this dynamic tool increases with usage. Second, since critical thinking requires concentrated intellectual effort, various cognitive tools (Jonassen et al., 1993) were integrated into the programme to decrease the heavy burden of information processing to facilitate understanding of complex data and support and enhance intellectual endeavours (Ferry et al., 1999).

In response to the identified needs, a generic software tool was constructed that would assist students to develop cognitive skills to be able to think like experienced practitioners in the workplace: The Interdisciplinary Critical Thinking Tool (TICTT). The tool was created as an interactive aid to assist with the delivery for course material in on- or off-campus learning situations, in any discipline. TICTT is structured on sound educational theories that enable students to experience a simulated workplace in the presence of experienced practitioners (cognitive apprenticeship) and extend learning to encompass solution-orientated outcomes. The tool uses discipline focused case-based scenarios to scaffold critical thinking (critical thinking and problem-based learning – PBL). As a teaching tool, it assists educators to engage students in flexible learning for their technological quest for knowledge.

The integration of cognitive apprenticeship, problem-based learning and critical thinking fosters a deep approach to learning and aids the learner to think in the culture of their discipline. This paper provides a discussion of how these educational theories coalesce with technology to form the theoretical foundation that informed the construction of TICTT.

Educational theories used to inform the development of TICTT

Cognitive apprenticeship

Apprenticeship is a well-recognized method for inducting novices into the community of expert practice of carpenters, lawyers and medical practitioners (Rogoff and Lave, 1984). Cognitive apprenticeship specifically involves the induction of novices into expert ways of knowing, thinking and reasoning (Brown et al., 1989). The characteristics of an ideal learning environment to support cognitive apprenticeship have been elaborated on by Collins et al. (1989) and provide a framework for the design of TICTT. Expert practitioners develop knowledge and tacit knowing through experience and contact with the realities of the discipline. Exposure to experienced practitioners’ ways of knowing offers students the possibility of entering the discipline with a work ready knowledge. In essence, knowledge and cognitive skills are learned through observation, coaching, practice and feedback with experienced practitioners in real life contexts.

After observing an expert execute an activity (modelling), the learner tries the task with expert guidance ( coaching). Whilst coaching, the expert provides reminders and feedback (scaffolding), which are gradually removed (fading) as the task is performed independently and with increasing proficiency. Coaching includes careful sequencing of instruction from simple to complex; increasing the variety of examples and practice contexts, proceeding from global to specific skills. Novices are encouraged to think about their actions and justify their decisions (articulation), analyse their own performance (reflection) and try out different strategies and observe their effects (exploration). As students gain more self-confidence and control, they move into a more autonomous phase of collaborative learning, where they begin to participate consciously in the culture.

Social interaction, social construction of knowledge and collaboration underpin learning the knowledge and ways of a profession. Exposure of novices to complexity, multiple ways of accomplishing a task and interaction with experts and peers helps learners to recognize that there is no one embodiment of expertise and encourages them to view learning as a continuing process (Vygotsky, 1978) embedded in a social milieu. The premise that knowledge and cognitive skills are best learned if they are embedded in the social and physical contexts in which they must be used (Brown et al., 1989; Norman and Schmidt, 1992) forms the philosophical basis of problem-based learning.

Problem-based learning (PBL)

Problem-based learning emphasizes the acquisition, retention and use of knowledge through the examination of real life situations using a structured reasoning process (Barrows, 1988). The reasoning process is frequently referred to as a hypothetical-deductive process. What this means is that a structured approach, similar to that used in scientific experimentation, is used to foster initial development of clinical reasoning or problem solving skills (Elstein & Schwartz, 2000).
Through exploration of deficits in learning identified through reflection and with the assistance of their peers, experienced practitioners or their teachers, students are motivated and have the capacity to generate their own knowledge (Norman & Schmidt, 1992). Resnick (1988) indicates that throughout most of our lives we learn and work collaboratively, not individually. In PBL curricula, a group of students work through a case and develop sophisticated group process skills as they negotiate learning and share knowledge with one another. Interaction with peers provides opportunities for consideration of different perspectives elaboration and articulation of knowledge in a collaborative and supportive environment (Barrows, 1988). The teacher’s role is to facilitate the learning process by:

- handing over the learning process to students;
- assisting students to make their knowledge explicit;
- keeping the reasoning process focused;
- strategically questioning the rationale underlying the inquiry strategy of the individual or group;
- prompting external self-questioning and reflection;
- adopting a didactic teaching role only when expert knowledge is critical to the case;
- posing questions to students that asks them to justify decisions; and
- providing accurate, specific and constructive feedback to students.

PBL begins with a problem scenario or a case study obtained from a workplace. To ensure validity it is imperative that the scenarios are designed from ‘real life’ situations to portray realism of the workplace. All information to create the case is gathered in preparation for its potential use as resource material. The teacher then designs a short story, written in strategic stages, usually known as ‘blocks’. There can be as many sets of block material as a case has to offer. The number can vary and the teacher can pace the blocks presented. The design of the material is crucial to the process. A number of specific cues or clues are placed in the case so as to trigger student inquiry.

Students pose hypotheses about the case with ‘It could be . . .’ statements. Once these statements are made students can then identify and seek the knowledge required, confirming or refuting the hypothesis statements. Student exploration of an hypothesis and identified learning issues form an essential step. Since problems have been framed from practice, the process compels students to think how to solve problems from a practice orientation. Students are also required to identify and document the resources they consider will need to be consulted to assist the enquiry.

Evaluation of the hypotheses is tested against the new knowledge gained throughout the learning process. Decisions or judgements are made on whether an hypothesis is to be accepted, rejected or perhaps retained when information was unavailable or unable to be resolved. The subsequent blocks are then presented and the sequence of investigation recommences. Once the case is exhausted, students have an opportunity to reflect; not just on questions or hypothesis posed of the case, but also on the learning processes and resources they used and the overall group process.

**Critical thinking**

Critical thinking involves the use of focused, self-regulatory judgment to assist with identification of a problem and its associated assumptions: clarifying and focusing the problem; analysing, understanding and making inferences; inductive and deductive logic; and judging the validity and reliability of the assumptions and available data (Kennedy et al., 1991). Whilst this view of critical thinking focuses on knowledge and intellectual capacities, it ignores important learning that is derived through experience and reflection in professional contexts that are characterized by uncertainty and ambiguity (e.g. law, nursing, medicine). Thus, for the purpose of the ✓TICTT project, critical thinking is seen as ‘a purposeful process of conceptualizing, interpreting, analysing, synthesizing, applying and evaluating information gathered from evidence, observation, experience, reflection, reasoning or communication’ (Facione, 1990; Scriven and Paul, 1996; Ip et al., 2000). These abilities are used to guide action upon which judgement is based. Most importantly, these decisions are made with contextual considerations, hence critical thinking can be considered as a process leading to the exercise of professional judgment.

**Overview of the ✓TICTT framework**

The ✓TICTT framework was initially conceptualized to acknowledge the unique contribution workplace practitioners can make to students’ learning. The overall template design assists students to develop thinking skills to think like experienced practitioners and thus facilitate graduate transition to the workplace (Stockhausen, 2000). ✓TICTT was further elaborated on, using an assessment tool developed for a PBL medical curriculum (Zimitat and Alexander, 1997). These elements provided the core design of the ✓TICTT as information
technology was integrated with the educational perspective presented. Throughout the development process, the two user populations considered in the design were academic staff responsible for the construction of cases, and students, the ultimate users of TICTT. Academic staff required a flexible system that can be structured and used in a variety of teaching and learning settings depending on the number and nature of students in their course and the level of the course. A case-building interface was a requirement for use by academic staff with a range of information technology skills. Finally, the whole student-work database needed to be available for download and future analysis.

From the perspective of students, TICTT needed to be engaging, motivating and enhance their critical thinking skills. The template incorporates text, image, sound and video data formats. Students and staff need to use TICTT on university staff computers and computer laboratories that are largely Windows-based. Students should also be able to access and run TICTT from any computer on-campus, from home and remote locations. It was a secondary requirement that TICTT operate across platforms and across browsers. The third requirement was that TICTT be designed to operate in conjunction with a discussion forum.

TICTT is designed for use in a variety of macro teaching and learning contexts (lectures, collaborative small-group tutorials or self-directed, independent study). TICTT enables authors to create a course consisting of several modules. Each module consists of several sequentially encountered sections: a model case, a reflective pause, up to three challenge cases and a debriefing element (Figure 1). The author can determine: the duration of the case; the number and type of questions posed; the number of resources made available; the particular focus of the case, where and whether the use of a discussion forum is made and the nature of other teaching and learning activities associated with the tool.

**Figure 1** The organizational structure of TICTT
A list of resources and an associated discussion forum are available at all times in the module. The author can hyperlink to external web resources (e.g. textbook), software or course material to assist students. The model case section allows the author to present sequentially a case scenario supported by multimedia elements (sound, images and videotape) and interspersed with questions. Learner users are requested to enter responses. They then have the opportunity to examine expert and peer responses to that question before revising their answer and continuing (Figure 2). There are opportunities for learners to review the case elements, see their original and improved answers and write personal notes. The reflective pause enables the author to focus the learner on one particular aspect of the case, their learning or past experience before they continue with the challenge cases. It can also be used as a natural break point for students to identify learning issues for further study before continuing.

The challenge cases section is intended to aid the transfer of cognitive skills to scenarios beyond the initial case encountered in the module. This section allows the author to present similar cases, or increasingly complex cases that draw upon learning and skills in previous modules. The case author might choose to use the discussion forum to facilitate interaction among peers, with experts to facilitate learning in this section or in the debriefing section where learner users have the opportunity to reflect on the module, their learning and the commentary of experts. Finally, an Online Case Builder facilitates construction of the modules and a Thinking Analyser facilitates report generation and research-oriented analysis of the underlying cumulative database of student navigation and peer responses.

Cognitive re-apprenticeship and design of \textit{TICTT}

\textit{TICTT} provides opportunities for learners to develop the cognitive processes (critical thinking) of experts within the constraints of the technology. The characteristics of ideal learning environment to promote cognitive apprenticeship identified by Collins \textit{et al.} Newman (1989) demonstrates how the design of \textit{TICTT} re-apprentices the

\textbf{Figure 2} A screen from the \textit{TICTT} prototype illustrating the student's view of the range of peers and experienced practitioners opinions regarding the issue under investigation. The learner is able to take notes during the process or reviewing peer and practitioner opinions for later use in revising their original answer.
learner to learn from the context and the experienced professional. The four domains of the model that support the notion of cognitive apprenticeship in the design on this tool are:

- content;
- methods;
- sequencing; and
- sociology.

✓ TICTT itself is a shell in which the author presents the content through controlled programming by using case scenarios (PBL) and expert opinions, in which peer opinions accumulate with program usage. Content-specific resources can be hyper-linked or added to the shell to serve as an aide-mémoire for student learning. Problem-solving strategies used by experts, shortcuts and tips of the trade (heuristics) are often embedded in the reasoning and commentary of experts. Through combination with other teaching strategies, the meta-cognitive capacities of experts can also be uncovered for learners.

Methods are both a teaching and learning characteristic. It is intended that the first case/scenario is the author’s opportunity to model the cognitive processes of experts. Comparative feedback provided from expert and peer opinion develops user’s analytical skills and serves as both coaching and scaffolding for learner users as they understand the elements drawn upon for expert practice. Learners develop their ability to clearly articulate their thoughts and reasoning through practice and observation, with an opportunity for discussion and feedback in a forum.

Reflection is promoted in ✓ TICTT through a number of strategies: opportunities for learners to revise and edit answers to questions, the ability to write personal comments in a cumulative note-book, and explicit questioning by the author. Finally, the discussion forum and opportunities within the program to ‘pause’ and research issues or use their own meta-cognitive processes before continuing with the program, facilitate reflection; perhaps the most powerful tool in the expert’s repertoire of practice (Schon, 1983).

Exploration involves placing students into a new problem-solving situation where they play the role of expert (Collins et al. 1989). In the challenge section of ✓ TICTT, students meet new scenarios, based upon their initial model case/scenario thereby enabling them to apply their knowledge and reasoning skills to broader topics. This extends their reasoning skills from content or context bound and enables these skills to be used in situations other than those in which they were learned.

Sequencing is achieved as the ✓ TICTT Online Case Builder encourages authors to build cases that include a narrative that leads the users through the case scenario in a logical and progressive manner. Cases are intended to build from prototype scenarios to more complex variations on the same theme or along combined themes arising from earlier modules. Use of a structured sequence of questions modelling simple reasoning (e.g. hypothetico-deductive reasoning) scaffolds student’s reasoning capacity before embarking on increasingly diverse and complex scenarios. This staging enables the learner user to build the various skills, language and knowledge base underlying expert practice.

Sociology within ✓ TICTT is created through multiple levels. The social construction of ✓ TICTT enables novices to ‘sit-in’ on the thinking and reasoning processes of an expert. The tool is designed for use in a lecture situation, by a small learning group in a tutorial or by individuals in a self-directed manner. Thus the environment created by the teacher largely determines the collaborative element. The linkage of a discussion forum raises opportunities for unstructured collaboration amongst peers and discussion with experts.

Evaluation

Designing software on an understanding of learning theory, does not automatically guarantee an effective teaching strategy (Laurillard, 1993): early review and subsequent evaluation of the software in the context of use is critical to determining its level of effectiveness and the type of learning it promotes. The first stage of evaluation required prototyping in Authorware and then in Cold Fusion to validate our proof-of-concept. The prototype was then used in the second stage to obtain feedback from discipline-based faculty members, learning development consultants and other education consultants about the program design and its possible use in teaching. Suggestions from this group, such as context sensitive help, a variety of question formats and the opportunity for registration rather than password access, have only been included in a redesign of ✓ TICTT functionality. Other suggestions such as dynamic branching were considered too difficult at present, but may be considered for future development. The next stage of evaluation, after final programming of the alpha product, will include feedback on usability and screen design through observation of and interview with of a group of interested academics and
students using three case examples provided from health sciences. Short-term and longitudinal studies in a range of teaching contexts in health sciences, biology and education are planned to ascertain the overall teaching and learning outcome and effectiveness of TICTT.

Conclusion

The TICTT program design is consistent with sound teaching and learning principles. It provides a relevant problem-based context for learning, actively engages the user and provides immediate comparative peer feedback to further encourage critical thought. Whether used alone, or in conjunction with other teaching methods, we believe TICTT will be a powerful addition to any learning environment.

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Biographical notes

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