2008

Using Design-Based Research For The Evolutionary Development Of An Online Metacognitive Tool

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One variable that is constant in educational technology research is that it is constantly changing. Online courses customised learning tools, media delivery systems and new pedagogies that might prove useful in advancing student learning spring up on a regular and constant basis. Given this constant evolution of new tools, how can educators track and monitor the value of new tools and skills learnt? The authors of this paper have developed an online metacognitive tool that helps students working in teams reflect on their learning strategies through a process of planning, monitoring and evaluation. The tool evolved through a process of iterative design using Design-Based research, a methodology that enables innovation in ICT, while ensuring methodological rigour.

Introduction

"Employers, universities and professional bodies agree that Australia needs to develop professionals who are highly skilled and ready to face the challenges of increased competition. More than ever we need professionals who are responsive to economic, social, cultural, technical and environmental change and can work flexibly and intelligently across business contexts" (DEST, 2007, p.1).

Increasingly, pressure is being applied to higher education institutions by both government funding authorities and employers to produce graduates with both technical and employability skills. The Employability Skills Framework, developed by the Australian Chamber of Commerce and Industry and the Business Council of Australia (DEST 2002), defines eight employability skills – communication, teamwork, problem solving, self-management, planning and organising, technology, life-long learning, and initiative and enterprise. However a recent study of higher education institutions has shown that these are not developed in a consistent manner (Barrie, 2006).

There needs to be a focus on developing skills that transfer beyond the academic environment to the work context. Authentic, interactive tasks are required in which students negotiate roles, reflect on their performance and are motivated to complete the work, because of its intrinsic value. In the learning environment outlined in this paper, students are required to form teams and develop products for real clients, which conform to industry standards. Within this setting an online tool has been developed (JAMTART) to address key generic skills inherent in teamwork. This product has been developed using design-based research through evolutionary cycles of development.

JAMTART

Over the past three years JAMTART has been evolving through iterative designs as an Electronic Performance Support System (EPSS), designed to promote the development of students' metacognitive processing abilities. Design-based research has been used to inform its development, and the first module has now been designed, developed and evaluated (Luca & McMahon, 2006). Offline approaches have been used to design the modules, with student feedback gathered and analysed to help in designing the online tool (McMahon & Luca, 2005).

In order to explore the nature of self-monitoring and conscious use of strategies, it was important the product be grounded within a context that supports these processes. Development of new media products provided a powerful mechanism for this. Graduates of Edith Cowan University's (ECU) Bachelor of Creative Industries in Interactive Media Development are typically required to follow an industry model that is based upon small teams developing products for clients.

The ability or inability to work in teams can be a crucial determinant of the success of technology development. This generic nature of this skill would require participants to develop and understand their role in the team, monitor their performance as they contribute to the overall team effort and then evaluate their performance with a view to further improving their performance. The goal, therefore was to develop a tool that could incorporate planning, monitoring, and evaluation of learning processes throughout students' experiences in the development of interactive media products. One common way of exposing such processes in the domain of teamwork is through self and peer assessment. Such assessment involves students making judgments about their own learning and that of others, which contributes to the development of autonomous, responsible and reflective individuals (Sambell, McDowell, & Brown, 1998; Schon, 1987). JAMTART was developed as the means to achieve this by tracking a student's progress through the life of a development project, and engage them in the above processes.

JAMTART is open source software (to be made freely available), and developed with administration, tutor and student views. Educators will have the flexibility to set up assessment criteria through the use of a wizard to help contextualise the tool to any discipline. As shown in Figure 1 and Table 1, the tool contains the following modules:

Table 1: JAMTART Modules and Tools

Modules	**Tools**
Self-assessment:	• *Self-assessment questionnaire*, which provides students with feedback on their • skills and attributes to help them make meaningful decisions regarding team • roles and responsibilities. *Team operational plan*, which is based on the results of the self-assessment questionnaire, as well as students' career aspirations. The plan outlines operational guidelines the team follows as well as the negotiated performance criteria for each allocated macro task. *Student Contract* which identifies the main (macro) responsibilities individual students have in the team. This ties into the unit's assessment criteria and allows students to clearly state what major roles and responsibilities they will take.
Team monitoring	• *Monitoring*. Each week, students enter their actual progress/performance (time, percent complete, quality and comments). This is compared to their estimated progress and performance as stated in the contract. This information is summarised and presented in graphical and tabular format to show how their roles and contributions within the team are evolving. This section concentrates on micro tasks that are related to macro tasks outlined in the student contract.
Reporting and reflection	• *Overall Evaluation & Reflection*. This portfolio tool shows summarised data such as comments, personal reflections and rationales for changes in estimations that evolved during the semester, and acts as a prompt for students to evaluate their overall performance. The emphasis here is for the students to explain *why* some tasks went off track, and why others were successful i.e. lessons learnt, skills that need enhancing and also areas of strength that can be carried forward in career options. These map back to unit outcomes and indicate the level of achievement obtained against those outcomes (low, medium or high).

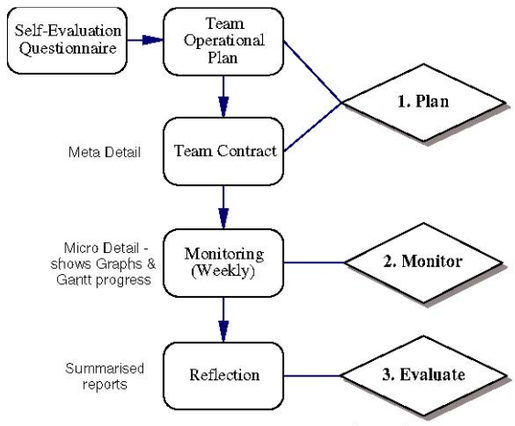

Figure 1: JAMTART – an online EPSS

Design-Based Research

JAMTART was developed within a design-based research framework which sought to combine applied local outcomes with broader research goals. Design-based research is often referred to as design experiments, but differs significantly from traditional experimental methodologies (The Design-based Research Collective, 2003). While analytic approaches to experimentation strive for objectivity and testing of individual hypotheses, design-based research aims to develop a profile of a learning situation. It embraces the fact that instructional settings are inherently messy, with multiple contextual variables that cannot be controlled or manipulated.

The aim of design-based research is to understand the situational factors and engage in a process of flexible design revision and social interaction rather than to control variables and use fixed procedures in social isolation. Ultimately the researcher is a co-participant in design and analysis rather than an experimenter. (Collins, 1999). It is "pragmatic as well as theoretical in orientation in that the study of function -both of the design and of the resulting ecology of learning – is at the heart of the methodology" (Cobb, Confrey, DiSessa, Lehrer, & Schauble, 2003, p. 9). This combination of both practical and theoretical components is underscored by Cobb et al. (2003) who identify five distinct features:

1 A focus on developing a class of theories about the process of learning *and* the means that are designed to support it.
2 An interventionist approach, acting as a test bed for innovation.
3 Building on the first two features, an aim of creating conditions for developing theories, but placing these theories in harm's way.
4 An iterative approach to design – the intended outcome being an explanatory framework that specifies expectations that become the focus of investigation during the next cycle of inquiry
5 The theory generated must do real work – rather than developing a generic theory that may be difficult to put into practice, design experiments speak directly to the types of problems that practitioners address in the course of their work

It is therefore a highly appropriate methodology for a study of this nature, which attempts to explore a theoretical model within the context of an innovative product design rather than test a theoretical hypothesis. Due to the heavily contextual and grounded nature of this form of research, prescriptive approaches to conducting design experiments are unavailable. Bannan-Ritland (2003) however, proposed an 'integrative learning design framework' to guide the process. This is a four-stage model:

1 Informed exploration
2 Enactment
3 Evaluation: Local Impact
4 Evaluation: Broader Impact

In developing JAMTART, the first stage was implemented through a literature review, and synthesis into a proposed design model, engaging in 'the essential research steps of problem identification, literature survey, and problem definition' (Bannan-Ritland, 2003, p. 22). The enactment phase consisted of the development and implementation of *JAMTART* within a setting, while the evaluation attempted to assess both the value of the product as well as its wider potential to inform the further development of theoretical and practical applications. The four-stage model is not a terminal one however. Rather, the end point of the four-stage model leads to further iterations and evolutionary development. This paper reports on the effects of the research, particularly with regard to the software design, and describes the results in terms of the next iteration of design that JAMTART is undergoing.

Feedback and Refinement

The product was implemented within the IMM3330 Industry Project unit. Participants consisted of 18 final year undergraduate students in a Bachelor of Creative Industries degree majoring in Interactive Media Development. Students were asked to complete a Likert Scale questionnaire on a five-point scale ranging from Strongly Disagree through to Strongly Agree, as well as some open questions including:

1 What was the biggest benefit/s to using JAMTART?
2 What improvements could be made to JAMTART?
3 Did JAMTART help make you aware of your learning processes and your performance in the unit as you used it? Why? Why Not?

The findings were presented in another report (McMahon & Luca, 2007), in three sections -usability of the product, value of the product as a tracking tool for teamwork, and an overview of the student experiences with this environment for planning, monitoring and evaluating their own learning. Most comments for improvement were centred on usability and interface issues. Based on this feedback, JAMTART is being redesigned to reflect a user's view, rather than an interface that needs to be understood. The three key users are students, tutors and administrators.

Figure 2 demonstrates the previous approach to the product structure. As can be seen, the system was predominantly built around the functional requirements of the product. While distinction was made between the administrator and student views, the product was organised around the modules – surveys, reports, and periods. In fact, from the end user's perspective there is a defined process that they would undertake, which will be implemented in the new design. The key metacognitive features of planning, monitoring and evaluation are fore-grounded in the more user-centric approach as demonstrated in Table 1.

Table 1: Redesigned structure of JAMTART

Access	**Feature**	**Description/Contents**
Administrator View	*Unit Management*	Add and edit unit details • Unit code • Unit title • Unit overview
Tutor View	*Unit Creation* ***Wizard***	Takes tutors through each of the four stages. Clicking on these will take them to other sections: 1. Periods -number of sessions needed for the project eg 12 weeks 2. Number of groups and size of each group 3. Surveys Needed: • Create and edit dimensions to be assessed • Develop statements and attach them to a Dimension • Create feedback for certain types of results • Creating rules to judge dimensions and • Attach the appropriate feedback 4. List of reports available with checkboxes showing student plans, actual times, and reflections. Reports selected here will be made available to the students

Access	Feature	Description/Contents
	Group Summaries	Clicking on the individual groups will allow the tutor to see: • Feedback for each member of the group • Job cards page (viewable but not editable) • Report results for each group or individual
	Student Management	• Student name • Student number • Email
Student View	*Unit Access* ***Wizard***	Students taken through a logical progression of: 1. *My Surveys* -lists surveys available. Clicking on them will allow student to complete or view results 2. *My Group* -view group members, join a group, select a role etc 3. *My Progress* -view schedule and job cards 4. *My Portfolio* -select reports & view portfolio

As can be seen, the redesign incorporates a more personalised approach, with 'My surveys', 'My progress', 'My group' and 'My portfolio'. At the same time, there are two wizards built into the system that promote the logical sequences involved in using the product. An example of this is the Unit Wizard. This allows the tutor to set up standard workflows for the students in a way that articulates the stages involved in engaging in the planning monitoring and evaluation of learning. Using a design-based research approach helped identify these requirements to make the produce more user-friendly and usable.

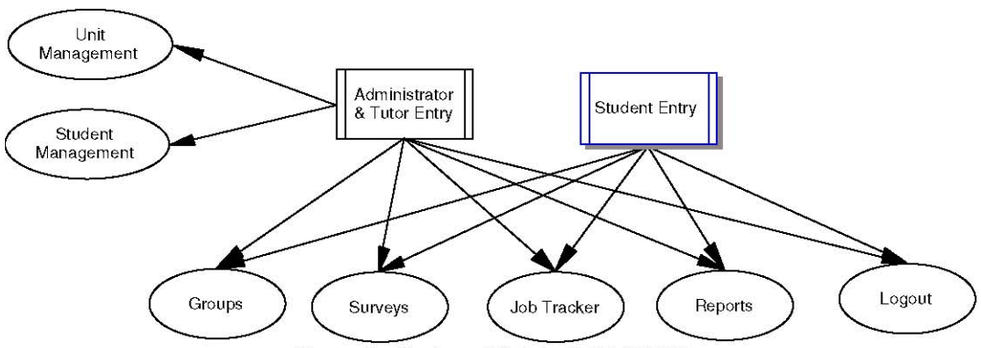

Figure 2: Design of Original JAMTART

Conclusions

Design-based research can support both local and broad research goals and its iterative nature allows an evolutionary approach to the evaluation and redesign of educational tools to support learning across a range of contexts. The learning environment discussed in this paper is the cumulative results of several implementations through several redesigns.

This paper has outlined the findings and redesign through one iteration of the design-based research process involving the redesign of an EPSS to support students developing metacognitive skills within teamwork settings. The redesign has provided a strong user-centric focus to empowering students to reflect on their learning experiences as they perform development tasks. The research is not finished.

As with all design-based research, implementation will allow further redevelopment and refinement to strengthen the product and further elicit understanding about the nature of planning, monitoring and evaluating performance when working in teams. However, the refinements that have taken place throughout this process have lead to a usable and effective product that can confidently be released within the next 6 months.

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