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Explorations in Metacognition: The design, development, and implementation of an online teamwork tracking environment

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Research shows that both metacognitive and cognitive strategies are needed for successful learning. In this study, an online tool was developed with a view to help students working in teams reflect on their learning strategies through a process of planning, monitoring and evaluation. An evaluation of the tool was administered at the end of the semester that showed the students valued the tool for tracking their teamwork, but weren't so convinced it help them plan, monitor and evaluate their learning. These results are discussed, and recommendations are made for improvement using a design-based research approach.

Introduction

To be effective members of their chosen industry, graduates need a range of skills that go beyond the curriculum of their specific discipline. Research into generic skills such as teamwork, problem solving, decision-making, communication and information literacy has shown that while many students do come to university with existing sets of skills in these areas, this is not true for the majority of students (Leamnson, 1999). As a result, 'Generic skills and graduate attributes have emerged as vital issues for both educational institutions and the communities that they serve, including students, employers and governments.' (Goldsworthy, 2003, p. 1). However a recent study has these are not developed in a consistent manner (Barrie, 2006).

Such skills can be identified as fundamentally metacognitive in nature in that they involve the ability to transfer skills across domains. Problem solving for example involves the ability to analyse situations, develop strategies and reflect on their performance. This becomes problematic because metacognition can be interpreted as an inherently internal psychological state. The issue for educators therefore is to tease out this concept and develop means to engage students in more manifest activities such as performance monitoring and strategy development which are underpinned by metacognitive processes (Schraw, 1995). So while metacognition can be defined as personal knowledge, which is generally not amenable to educational intervention, it is also characterised by task knowledge and strategy knowledge, which is more evident and easy to identify through objective means (Wenden, 1991). In this sense, therefore metacognition is 'knowing the process by which one learns', but also 'the self-monitoring of, and conscious use of learning strategies' (Jacobson,1998, p. 3).

This paper reports on the design, development, implementation and evaluation of JAMTART - an tool to promote self-monitoring and conscious use of learning strategies within the domain of teamwork within Interactive Media Development projects. The tool was implemented within a class of students of project management for Interactive Media in the first half of 2007. The study took the form of design-based research, with the use of a beta version of the product to explore the nature of metacognitive processing within the tool and to inform the continued development of the tool.

Design of JAMTART

The initial stage of the development of JAMTART was to conduct a review of the literature to identify the explicit primary processes that underpin all metacognitive activity. Nelson and Narens (1994) developed a simple but influential model of metacognition that defined it in terms of a reciprocal flow of information between object and meta-level thinking that involved a monitoring activity and then controlling it as a result of monitoring. Fogarty (1994) expanded on this concept to define metacognitive monitoring in terms of planning, monitoring and evaluation. This formed the theoretical basis of metacognition as it was manifest in JAMTART.

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 judgements 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. The three basic metacognitive processes of planning, monitoring and evaluation as they were evident in the product are outlined in Figure 1.

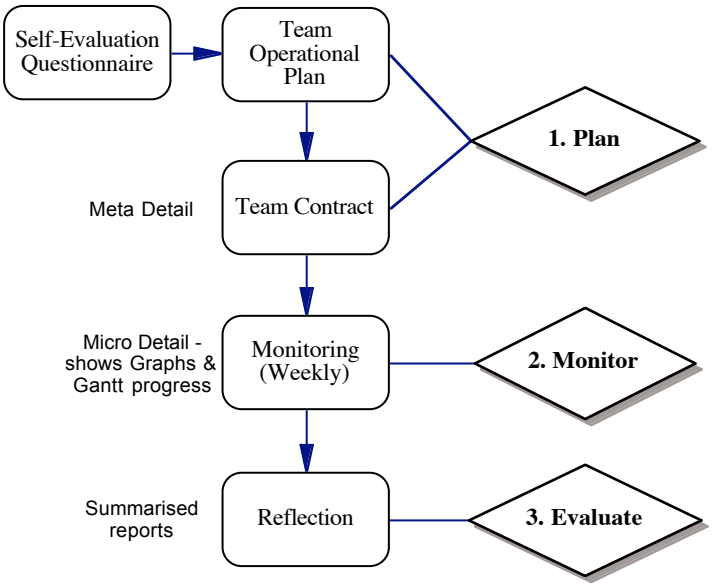

Figure 1: A schematic view of the structure of JAMTART

The approach is broken down into a number of phases that users would go through that were tied directly to the product development lifecycle, while identifying key stages of metacognitive processing that occurred at each phase of the lifecycle. Ultimately, JAMTART was conceptualised as a suite of discrete modules integrated into a whole. Specifically, the product consisted of:

- A self-assessment tool
- A team monitoring tool; and
- A reporting and reflection tool.

The initial phase of team development and the setting of team goals, milestones, individual responsibilities and so on are inherently planning processes. One could legitimately argue that planning is like predicting the future – anyone can do it, but the hard part is getting it right. For that reason, the process of planning is not treated as a one that takes place within a vacuum. The first role of the product is to provide a means for users to make plans. To that end, JAMTART was built in a modular fashion with the first module dedicated to the process of self-assessment. This provided a basis for the formulation of plans.
The second module was designed to allow users to monitor their performance as they progress throughout the iterations of development in their projects. It provides a breakdown of jobs and activities within specific periods and allows users to track their performance as well as the performance of others.

The final report builder has a role in providing visual and table based summaries of the activity within the product throughout the whole development. This reporting tool acts as a way of prompting reflection on the part of the user. From a project management perspective it acts as a means of conducting a post-mortem about the project. From a metacognition perspective its role is engaging the learner in the process

of self-evaluation to round off the planning, monitoring and evaluation process. Each of these modules is described and illustrated in the following section.

Self-assessment tool

The self-assessment tool consists of a generic rules-based system that allows administrators to set up likert scale tests, judge the responses and provide feedback on user performance. A student view of the self-assessment tool is shown in Figure 2.

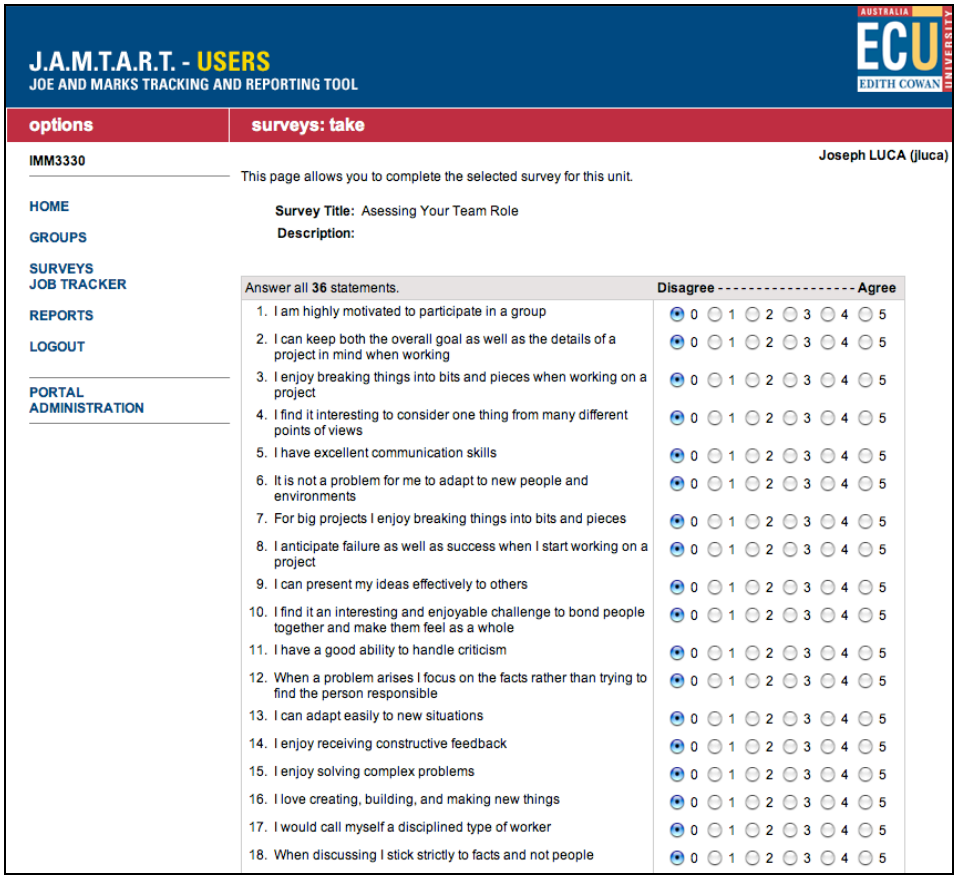

Figure 2: Self-assessment tool - users view

Beneath quite simple looking system is a fairly complex set of rules that need to be developed to provide feedback for users. The Four main components required in setting up an assessment are:

- Dimensions
- Statements
- Rules; and
- Feedback

Dimensions are set up as categories to group survey statements. Each statement created is attached to a specific dimension that indicates the concept which the statement addresses. In the case of this implementation of JAMTART, the dimensions related the skills inherent in team-based projects. Therefore, each statement addressed one of the dimensions of accepting criticism, communication, creativity, leadership, problem solving, and teamwork. As can be seen, dimensions can be used to address generic skills themselves. The administrator's view of the statements component is shown in Figure 3.

Once each statement has been developed and attached to a dimension, rules need to be designed that judge the results that are created when an end user fills out the online questionnaire.

Rules can be developed based upon simple Boolean logic. How they respond to certain dimensions in comparison to others dictates the nature of the feedback that users receive. The process involves comparing dimensions based on operators such as greater than, equal to, more or less than a certain percent positive response and so on. These rules can be nested and therefore become quite complex as

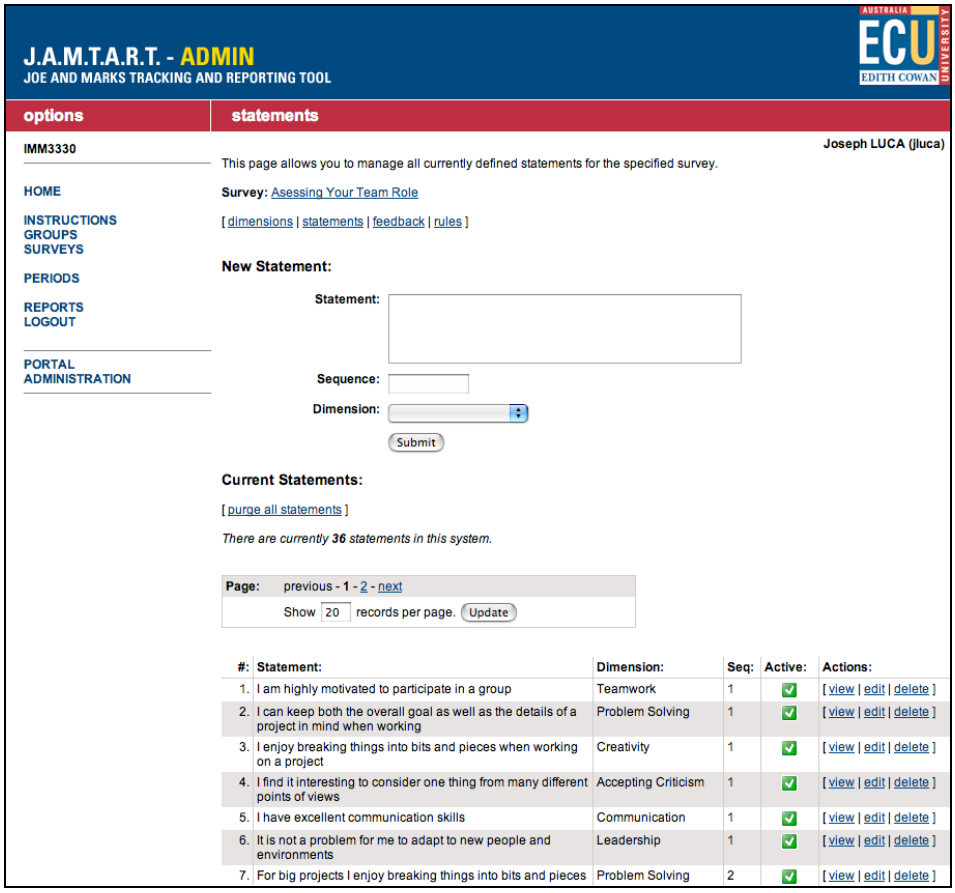

Figure 3: Statements in the self-assessment tool: Administrator view

shown in Figure 4, which demonstrates ten rules applied to judge the extent to which a user's response shows a predisposition towards the role of being a graphic designer. In this example feedback was created and attached to the rule, which would then be displayed for the end user if the rule criteria were met.

While the self-assessment tool can be used to create feedback on users' performance on any type of likert scale questionnaire created within the tool, in this case, the rules, statements, feedback and dimensions were created to assist learners in defining a role within a team. Students generated their roles within JAMTART and these then carried through to the team monitoring tool.

For each job and for each period, Job cards are filled in by users and then revisited at the end of that period for reflection and to identify what went wrong or right and what changes need to be made to the schedule of next period. These changes to individual job cards are then automatically updated in the Job Tracker.

Team monitoring tool

In a sense, the Team monitoring tool can be seen as the heart of JAMTART as it is the tool with which learners would spend the most time, being required to work with it at regular intervals during the project management lifecycle.

The tool has much in common with existing project management tools, but has the important distinction that it maintains an audit trail of users performance throughout the project, and acts as a tool to capture users' reflections on that. In this sense, it includes planning and evaluation, but through a process of continuous monitoring and reconfiguration of plans based upon formative evaluation.

The main components of the Team monitoring tool are the Job Tracker and its subordinate Job Cards. As team members select roles jobs, and identify timeframes for their completion they appear to the team in the form of a project summary.

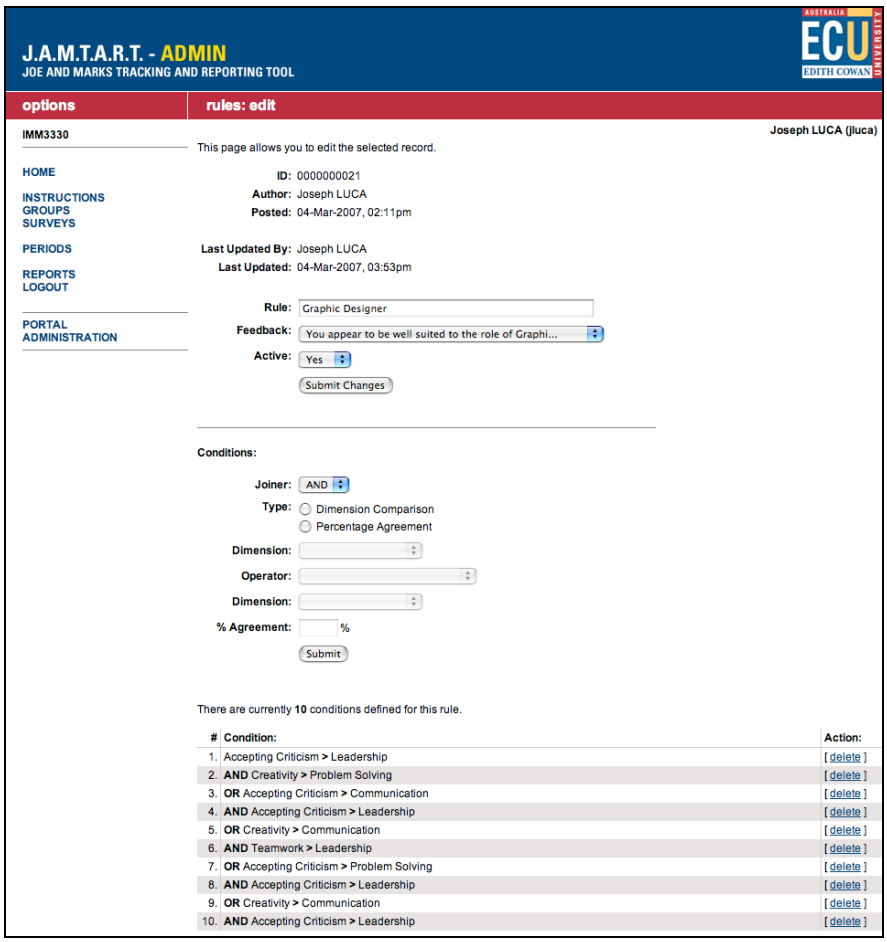

Figure 4: Rules and feedback: Administrator view

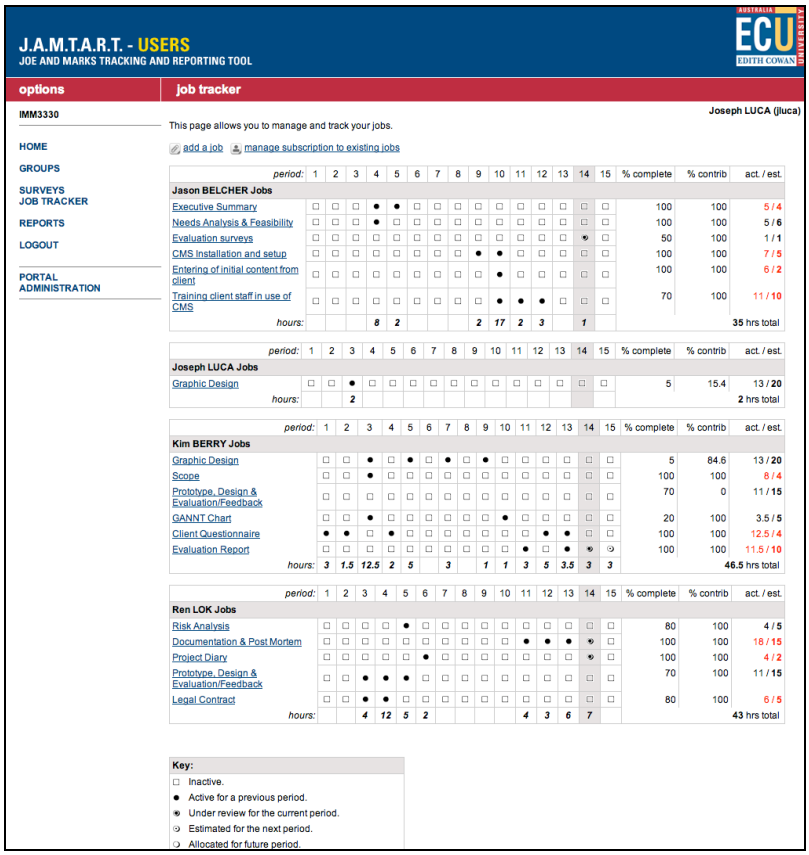

Figure 5: Job tracker: User view

Reporting and reflection tool

As can be imagined the Team monitoring tool results in the collection of a significant amount of data about individual and team activity throughout the project. Attached to these are the ongoing reflections made by the users as they review their performance and reconfigure their plans through the job card system.

Ultimately to work effectively as a tool for final self-evaluation, these forms of data need to be summarised in a manner that assists learners in reflecting on their performance. This was achieved within JAMTART through the reporting and reflection tool. This component enables the following reports to be generated from a team's dataset within JAMTART:

- Actual hours
- Individual job history
- Individual vs. group contribution
- Job by job project summary; and
- Project reflections

An administrator can attach prompts for comments from end users on each report. The first four of these are focused closely on the actual data generated from the team monitoring tool. The final report, however, can be created by administrators to address more holistic issues through specific questions asked of end users that enable them to articulate their experiences in their own words as a project post-mortem.

An example of a job-by-job project summary is shown in Figure 6. This demonstrates a visual summary of each job through a graphical chart depicting actual vs. estimated hours. Other forms of summary include tables of job cards with their attached comments, overviews of the performance of each member of the team and so on.

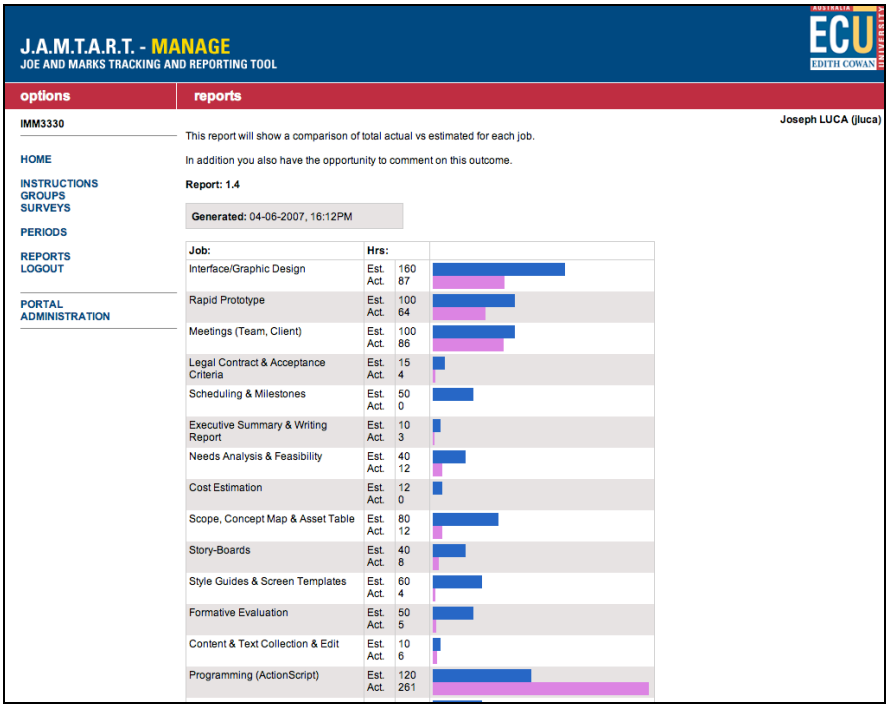

Figure 6: Job by job project summary: Administrator view

As well as a prompting and reflection tool, this part of JAMTART was also designed to provide a basis for assessment of effort. Each person's set of reports can be viewed as an e-portfolio and then used as a discussion tool to deal with issues such as workload inequity.

Methodology

The study was conducted within the paradigm of design-based research. This approach to research is characterised by the combination of narrow and broad research goals, as well as an iterative approach to design and development (The Design-based Research Collective, 2003).

Key features of design-based research include:

- A focus on developing a class of theories about the process of learning and the means that are designed to support it;
- An interventionist approach, acting as a test-bed for innovation;
- Building on the first two features, an aim of creating conditions for developing theories, but placing these theories in harm's way;
- 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; and
- 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 (Cobb et al., 2003)

This approach was exemplified within this research through the focus on the application of a theory to the development of an innovative product. The aim was to test theory through the practical implementation of the JAMTART within a real setting. It was subject to both narrow and broad research aims. At its most narrow level, the study sought to evaluate the product in terms of its utility and useability. At a higher level, it investigated the value of the product as a tool for tracking the teamwork that took place over the semester as students engaged in their projects. At its broadest, the research aimed to explore the extent to which the self-assessment, tracking/monitoring, and evaluation/portfolio components helped to promote the planning, monitoring and evaluation inherent in metacognitive processing.

The product was implemented within the IMM3328 Project Management Methodologies unit. Participants consisted of 11 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 (Table 1) 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?

Table 1: JAMTART questionnaire

	Question	Average Score (/5)
1	JAMTART was useful in helping me track my own progress	4.4
2	The environment allowed the team to quickly track their progress	4.8
3	The end of semester reports produced by JAMTART helped the team analyse its performance	4.6
4	Having to comment on my performance in the final reflective report helped me understand how I contributed to the team's effort over the semester	4.8
5	The self assessment tool used at the beginning of the semester helped me define my role in team	4.7
6	I found JAMTART easy to use	4.5
7	The weekly time sheets effectively tracked performance on jobs throughout the semester	4.4
8	JAMTART helped me plan my learning	4.3
9	JAMTART helped my monitor my learning	4.3
10	JAMTART helped me evaluate my learning	4.3
11	Overall, JAMTART was useful as a tool for developing team project skills	4.4

The data was used to provide findings to inform the continued development of JAMTART. Importantly, design-based research is iterative in nature. JAMTART was implemented as a beta product among a small group of students within this initial stage. Development of the product is continuing and the research is ongoing. This paper presents findings on the initial implementation identifying key findings regarding its useability as a product, its ability to support teamwork tracking, and initial experiences of end users in terms of the extent to which it helped them plan, monitor and evaluate their learning.

Findings

The findings are presented 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.

Useability of product

The JAMTART online application was deployed in semester 1, 2007. However, the full application had not been developed at the beginning of the academic teaching week. The survey module was ready for week 2, though the team-monitoring tool wasn't ready until week 3. The reporting and reflecting tool wasn't developed until the end of semester, so the students couldn't see what the end product/reports looked like. This is reflected in the following comments:

> At first I wasn't sure what it was all about. Only really in the last week, the reports clarified what the tool was doing. I think some examples of the how the final reports will look would be very useful at the beginning, and during the semester

> I didn't really understand that the tool was trying to get me to reflect on my style of learning until the end. It would be good to maybe see some of our own reports earlier to get a feel of how we are going.

Some students thought the interface could be improved, though were very positive after the instructor guided them through the key areas. They enjoyed being able to quickly and easy enter tracking information for their roles within the team, while at the same time seeing how their peer were performing.

Tracking tool for teamwork

Students were very positive about the benefits of JAMTART in helping then track teamwork tasks and performance. They perceived the environment easily allowed them to track their own, and their peer's progress, as well as helping them understand how they contributed to the team's overall effort through the reflective reports generated at the end of semester. Typical comments include:

> Great way of checking the progress of all the team members. Last semester, it took a while to get updates of where other team members were at, and how much time they had put in. This tool always showed us everybody's state!

> It's very honest. You really know what everybody in the team is up to, so they can't really get away without doing their jobs.

At the beginning of the semester students were asked to complete the online self-evaluation survey (Figure 2). Students received feedback on key generic skills needed in team-oriented projects, based on their responses. Comments and responses to this survey tool were positive, even though the feedback was not always completely accurate (as determined by the rules defined by the researchers). The feedback had the effect of encouraging students to reflect on these skills, and critically review the feedback eg "*You seem quite inflexible and do not seem to work well with others",* or *"You seem to be a good team player, but your communication skills need some work".*

Students discussed this feedback in their teams that helped shape their roles, or skills they would try to cultivate during the semester. At the end of the semester they were then encouraged to reflect on they performed within their team roles. Even though students were positive about the value of JAMTART in tracking their efforts within the team, they weren't so positive about its ability to develop their team project skills. Typical comments about the value of JAMTART in helping them track teamwork tasks included:

> It was great at the end to see a report summarising all my efforts, what I had done, and how it compared to the rest of the team. Reflecting on this was useful, as it packaged up a full semester of work. I found this a very rewarding thing to do, and it was also very quick and effective as the data was all online.

> I really enjoyed seeing a summary of all the data and how I compared to the rest of the team. It was useful to see how I performed during the semester, and helped me reflect on what I contributed to the team.

An environment that promotes planning, monitoring and evaluation of my learning

Overall, students felt that JAMTART was limited in helping them plan, monitor and evaluate their learning. Most of the responses and comments were focused on its value as a team based tracking tool. This was clearly a result of not introducing JAMTART in a holistic manner at the beginning of the semester, as reflected by this student comment:

> I didn't get it. I didn't realise that it was tracking my learning or performance until the reports at the end asked me to comment on these things. More information earlier about what it was doing might have helped *with this.*

In the next implementation of JAMTART care will be taken to clearly explain all its features. Examples of planning surveys, weekly monitoring, and end of semester reflective reports will be shown at the beginning of semester to illustrate how the tool can help the reflect on their learning as well as track the teamwork tasks. Ultimately, while the product suffered from a failure of a clear articulation of the theory throughout the tool for the student, it raised some interesting about the nature of design-based research as both an iterative approach to research and as a philosophy that places theory 'in harms way'. In many respects the pilot JAMTART failed to provide clear evidence of the end product of metacognition, however that in itself provided useful evaluative feedback for further iterations of the product and the research. The fact that students did not strongly assert JAMTART's value in helping them develop metacognitive skills does not necessarily mean metacognitive processing was not being developed throughout its use. Self-reporting methods of data collection can be problematic in trying to obtain valid evidence for complex phenomena such as metacognition (Ericcson & Simon, 1980). The next iteration of the research will endeavour to explore the concept of metacognition in more grounded and complex ways.

Conclusions and recommendations for improvement

One area for improvement is in the role of direct instruction to promote the product as a metacognitive tool. Scruggs et al. (1985) emphasise the role of strategy instruction in enhancing and debriefing the thinking process. To promote the product as a metacognitive tool, students in the next implementation will be given greater instruction about metacoginition as well as implicitly engaging in it. Each week student teams will be asked to discuss their planned and actual progress and show their tutor. This will help detect any discrepancies in estimated and actual progress within the team, as well as remind the team of key milestones and responsibilities. Discussion will focus on original plans, versus actual progress. Students will be given the opportunity to discuss their progress, and give reasons for both positive and negative results. If their current strategies aren't working to achieve the planned tasks, what strategies will they try improve or succeed in the following week? Summaries of these will be entered into JAMTART. This explicit strategy instruction has the potential to draw out the metacognitive processes that students engage in and help them to engage in planning, monitoring and evaluation of their thinking in a more informed and deliberate manner. Also, the reflections generated within JAMTART will allow for a textual analysis to identify evidence of metacognitive cognitive processing in reports generated within JAMTART. These can then be further used after the implementation when interviewing students about their thought process, as a prompt within a process of Stimulated Recall (Miles & Huberman, 1984). This data collection method has the potential to provide a means of eliciting feedback from students that is more grounded in their direct experience of a product rather than simply drawn from general assertions.

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