

'I am not a Person with a Creative Mind': Facilitating Creativity in the Undergraduate Curriculum Through a Design-Based Research Approach

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Abstract: Today's graduates need the skills to enable them to 'persevere in the face of complexity and unresolvability' (McWilliam and Haukka 2008: 660), and to respond creatively in work environments that are increasingly dependent on digital technologies (Cunningham 2006). However, although many higher education institutions (HEIs) acknowledge the importance of creativity within the curriculum (McWilliam 2007a), it is argued that universities are failing to equip graduates with the creative skills they require to be effective in the workplace. Design-based learning (also referred to as learning by design) is ideally suited to facilitating the development of creative problem solving (CPS) skills by engaging students in complex learning activities involving the active construction of knowledge through a series of iterative cycles of experimentation and refinement of concepts (Naidu 2004). Similarly, design-based research (DBR) involves a series of iterative steps to design and develop learning environments and theories the design, while also informing the development of practical guidelines (Reeves, Herrington and Oliver, 2005). This paper reports on findings from a project funded by the Australian Government Office for Learning and Teaching, which aimed to develop a CPS framework and supporting online system to scaffold teachers and students through a creative problem solving approach founded on the principles of DBR. The study employed a mixed-methods DBR approach involving multiple iterations to design, develop, trial and implement the framework and tool, as well as the development of principles and practical guidelines for application in the classroom. The findings reported in this paper focus on the DBR process and the experience trialling the CPS tool in a first-year undergraduate course offered in the School of Communication, International Studies and Languages at the University of South Australia. The paper reports on the implications of the findings from the project and the benefits of DBR as a methodology informing the design, development and implementation of a technology enhanced learning approach to fostering CPS in the undergraduate curriculum.

Keywords: Creativity; Creative Problem Solving; Design-Based Research; Higher Education; Graduate Attributes; Generic Skills

1. Background

The need for a more creative workforce able to respond to complex and uncertain times is well established (Craft 2006; Florida 2003; McWilliam 2007a; Pink 2006). Creativity and innovation are crucial to the success of businesses in the networked information society of the 21st Century, necessitating graduates who are able to undertake creative work in environments that are increasingly dependent on digital technologies (Cunningham 2006). Recognition of the changing demands in a knowledge based economy and the need to better prepare graduates with 21st century skills (*Transforming Australia's Higher Education System* 2009) has refocused attention on the need for universities to foster the development of graduates' employability skills such as the ability to communicate effectively, solve problems, work in teams and think creatively. This emphasis is also evident in the Australian Government's HEI funding strategy, with its focus on the employability of graduates and the production of graduates who are 'work ready' (Harvey & Shahjahan 2013).

The Australian Government has also highlighted the central role that creativity plays as the driver of social and economic success. In a report arising from the Australia 2020 Summit held in 2008, 'creativity, interpretation, innovation and cultural understanding' are identified as core skills required by the industries of the 21st century' (*Responding to the Australia 2020 Summit* 2009: 193). Yet despite this recognition of the central role of creativity and innovation in the workplace, many argue that universities are failing to equip their graduates with these skills (Craft 2006; Tosey 2006). Moreover, although creativity, creative thinking and innovation are generic skills required for life-long learning, as with many other generic skills identified by employers, these skills do not feature in any Australian graduate attributes statements (Oliver 2011). Although HEIs acknowledge the importance of creativity within the curriculum (McWilliam 2007b), many programs focus on particular kinds of graduate attributes and traditional educational approaches, rather than employability skills

relating to creative thinking and creative problem solving (Gluth and Corso 2009; Wood et. al. 2011; Wood et. al. in press). There are also many pressures on teachers in HEIs, where there is an intolerance to ambiguity, lack of time and space for experimentation, fear of making mistakes, high levels of stress, and the lack of a sense of challenge (Byron 2007), which contribute further to their resistance to embedding creativity in the curriculum. Emphasis in education has been mostly concerned with what De Bono (1973) calls vertical thinking; the process of proving and developing concept patterns, whereas lateral or creative thinking sets out to restructure such patterns and provoke new ones.

One of the major barriers facing teachers wishing to incorporate creative approaches in their teaching and learning has been the lack of explicit guidelines and a scaffold to guide them in making the required shift from outmoded teaching approaches to more innovative approaches to embedding creativity within the curriculum. This is especially so in discipline areas outside of design and the arts (Gluth and Corso, 2009). Tosey (2006: 35) suggests that creativity in the higher education curriculum is more often used 'to converge and control' than to engage productively 'at the edge of order' (Fullan, cited in Tosey 2006: 34). To change this prevailing culture, argues Jackson (2006), we need to change our approach from penalising mistakes to one of appreciating that making 'mistakes' provides important lessons for learning. 'By perceiving 'mistakes' as opportunities for, and proof of, learning instead of failure, we begin to change the paradigm to one that is more enabling and valuing of creative effort' (Jackson 2006: 197).

Another potential reason that universities have failed to embrace creativity in the curriculum more widely across different disciplinary fields is the lack of a concise definition of creativity within policy documentation (McWilliam 2007a). Edwards (2000) suggests that the term 'creativity' has an amorphous nature; a gift that is only possessed by an exceptional few. However, research has drawn attention to the importance of fostering the creativity of all learners (Csikszentmihalyi 1982; McWilliam 2007a). Researchers are also challenging the assumption that creativity is purely an innate capacity and cannot be learned (McWilliam 2007a; Robinson 2001), and they have demonstrated that human intelligence is complex and multifaceted (Robinson, 2001). Creativity is enhanced by other capacities and learner motivations and also influenced by the cultural context; cultural conditions can kindle or kill creativity (Robinson, 2001).

A third barrier to changing the educational paradigm in ways that foster the creative capacities of future graduates relates to the lack of strategies to help teachers develop the skills to engage with creativity 'intentionally as an outcome of pedagogical work' (McWilliam 2007a: 4). Fostering creativity is 'best achieved through a process-based or activity-based curriculum that engages students in challenging, novel and unpredictable ways of working and learning' (Jackson 2003 cited in Jackson 2006: 213), however, the strategies for achieving this goal are less evident for teachers. The following sections outline an approach aimed at addressing these three barriers through the design and development of a CPS framework and associated tools to provide a scaffold to teachers in the design of their curricula, and to guide students in applying the skills of creative problem solving in their studies.

2. A Systems Approach to Creativity

Creativity is the process of creating novel and useful ideas or products (Dewett 2003). Although creativity can be learned and assessed, the learning environment will either facilitate or impede the achievement of creative performance. A CPS framework needs to be able to be adapted to suit the domain and field of study, while also accommodating individual student needs by taking into consideration their abilities and preferred learning styles. Such a framework also needs to optimise the opportunities both divergent and convergent thinking, risk taking, evaluating decisions, and synthesising existing and new information in order to arrive at an optimal outcome. Finally, the framework should address strategies to maximise the conditions under which the experience of learning will be its own reward (referred to by Csikszentmihalyi (1996) as being in the 'flow').

Amabile (1996) identifies three components of creative performance: 1) domain-relevant skills; 2) creativity-relevant processes; and 3) task motivation. Such an approach is consistent with Csikszentmihalyi's (1999) systems approach in recognising that domain-relevant skills (for example, facts, principles, technical skills, and opinions) are required for a student to be able to assess the range of response possibilities and to be able to synthesise the information against which the new response is to be judged (Csikszentmihalyi 1999; Dewett 2003). Creativity-relevant processes determine the degree to which a student's response will surpass previous

responses in the domain (Dewett 2003), while task motivation refers to the student's attitude and motivations for undertaking the task, as well as his/her understanding about why the task is being engaged (Amabile 1996; Dewett 2003). Again, consistent with (Csikszentmihalyi (1991), Amabile agrees that creativity is more likely to be facilitated when the task is intrinsically motivating (the experience of learning is its own reward) (Csikszentmihalyi 1991).

The principles of CPS have been attributed to the pioneering work of Alex Osborn who developed the approach as an aid to the understanding the different phases of creative problem-solving (Isaksen and Dorval 1993). The Osborn-Parnes CPS model is a modification of Osborn's CPS approach, comprising three major stages: 1) exploring the challenge; 2) generating ideas; and 3) preparing for action, and six steps within those stages: 1) objective finding; 2) fact finding; 3) problem finding; 4) generating ideas; 5) solution finding; and 6) acceptance finding (Creative Education Foundation 2010). This model is depicted as a cycle, recognising the need for flexibility and that creativity tends to function in a more cyclical than linear pattern. Variations of the model have been used across a range of disciplinary fields and for various purposes including the development of educational materials (Torrance 1978), to facilitate inclusive education (Giangreco et al. 1994), and as a framework to support the marketing curriculum (Titus 2000). Amabile's (1996) componential framework of creativity incorporates a similar CPS approach, but in this approach, the components of the creative performance (domain-relevant skills, creativity-relevant processes and task motivation) that impact on the individual's creative performance are also considered. All CPS approaches acknowledge the iterative nature of the problem solving process and the need for both divergent thinking (particularly during the early stages of the cycle) and convergent thinking as ideas are further refined.

3. Design-based research (DBR) approach

Design-based research emerged as a methodological approach in the 1990s (Brown 1992; Collins 1992) in response to the need for educational research that produces 'new theories, artifacts, and practices that account for and potentially impact learning and teaching in naturalistic settings' (Barab and Squire 2004: 3). DBR addresses complex problems in real contexts, builds on theory and design principles to implement technology enhanced innovations to address the identified complex problems and involves reflective inquiry in the process of designing, trialling and implementing innovative learning environments. DBR differs from action research in that DBR should result in the creation of new design principles and practical guidelines for teachers (Anderson and Shattuck 2012; Barab and Squire, 2004; Reeves, Herrington and Oliver 2005). The Design-Based Research Collective (2003) identifies five characteristics of DBR:

- The process of designing learning environments and developing theories are central to the approach.
- The research process involves continuous iterative cycles of design, enactment, analysis, and redesign.
- The research leads to theories that are of relevance to teachers and educational designers.
- The research is undertaken in 'authentic' settings and documents the successes, failures and interactions in the local context to better understand the implications for applying in other contexts.
- The methods connect processes of enactment to outcomes.

DBR was chosen as the research approach for the study reported in this paper, and in keeping with the characteristics of DBR, our research team comprised teachers, researchers and designers working in collaboration and the research approach employed mix-methods with multiple iterations involving designing, developing, trialling, evaluating, reflecting and redesigning informed by the previous iteration.

3.1 Research method

The project commenced in October 2011 and is on-going. The initial project aims were to design and develop a CPS framework (<http://www.creativity-project.net/cpsframework.php>) and open source online CPS tools to act as a scaffold for teachers in the development and redevelopment of courses (*Ingenium Teacher's Tool*) and a CPS tool for students (*Ingenium Student's Tool*) to guide them through the creative problem solving process in their coursework. The project also aimed to develop guidelines, case studies of the use of CPS in courses across a range of disciplinary fields and a suite of resources available via the project site.

The research approach involved six major stages reported in the following sections. While the CPS tools were trialled in ten courses, this paper reports the findings from only one of the courses; an undergraduate course, *Introduction to Digital Media*, undertaken by students enrolled in various undergraduate programs in the

School of Communication, International Studies and Languages at the University of South Australia. The findings of the trials of the CPS tools in all ten courses are documented in full in the final report (Wood et al, in press). Details of each of the stages undertaken are presented in the following sections.

3.1.1 The design of a CPS model

The first stage of the research involved the design of the CPS model and framework informed by theories of creativity. The team drew on the seminal literature on creativity (Csikszentmihalyi 1982, 1991, 1996; Torrance 1978) and contemporary research such as Amabile's (1996) componential framework of creativity and Titus's (2000) CPS model in the design of the CPS framework and model. The adapted model developed for the study involves six stages (Figure 1), which correspond closely to the Titus (2000) model. However, in our adapted model we use the term 'response generation' rather than 'idea generation' for the fourth stage of the process because we view idea generation as fundamental to each stage of the creative problem solving process. Thus, idea generation is embedded in each stage of the process with alternating divergent and convergent ideation, shifting toward convergent thinking by the final stages of validation and completion/implementation (Brophy 1998). Our model also recognises the impact of the domain, field, and individual factors (Csikszentmihalyi 1999).

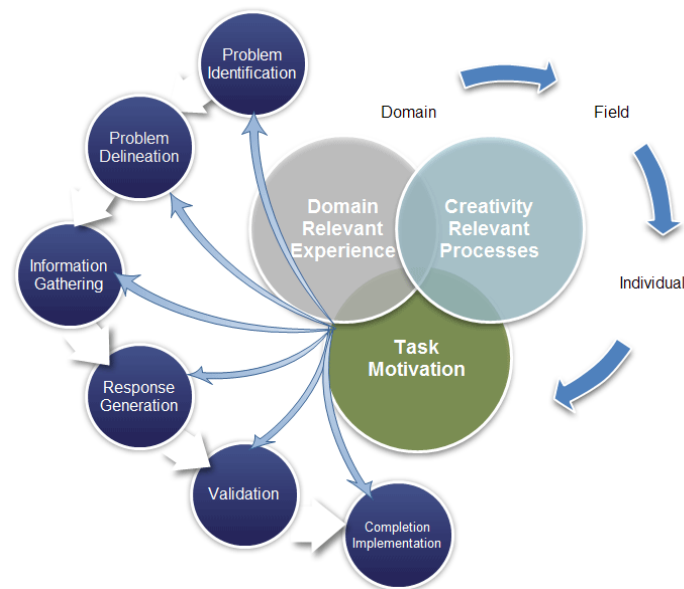


Figure 1: A Systems Approach to Creative Problem Solving (CPS) adapted from Amabile (1996), Csikszentmihalyi (1999) and Titus (2000)

3.1.2 The development of a CPS framework

The model developed during the first stage of the research process provided a conceptual overview of the processes involved in creative problem solving as well as the factors likely to impact on the way in which students engage with the approach. This model informed the development of a CPS framework incorporating the major stages of the creative process with associated practical techniques to guide teachers, and support students undertaking activities requiring them to apply the principles in practice. The techniques have been adapted from the idea generation techniques informed by the work of (Titus 2000), Gluth and Corso (2009) and The Global Creativity Corporation. The framework shown in Table 1 condenses the six stages identified in the CPS model into five major steps: 1) problem identification; 2) problem delineation; 3) information gathering; 4) experimentation and validation and implementation. Each stage in the CPS framework incorporates a list of techniques designed to assist students in generating ideas, classified according to whether the techniques involve visioning, modifying, exploring, or experimenting.

Table 1: A Framework for Creative Problem-Solving using Idea Generation Techniques adapted from Titus (2000), Gluth and Corso (2009) and Innovation Styles and Market Comparison (The Global Creativity Corporation)

CPS Stages	Idea Generation (ideation) Techniques			
	Visioning	Modifying	Exploring/Discovering	Experimenting
Problem Identification	<p>Fluency of ideas involving generation of large number of possibilities</p> <p>Brainstorming</p> <p>Use of guided imagery</p> <p>Collaborating and discussing to generate ideas</p> <p>Using social media to enable community to submit their ideas</p> <p>Using blog to reflect</p>	<p>Refining what others have done using:</p> <p>SCAMPER technique: (s)ubstituting (co)mbining (a)dapting (m)odifying (p)ut to use (e)liminating (r)arranging</p> <p>Modifying ideas based on peer feedback and discussion</p> <p>Using social media to create mash-ups of ideas</p>	<p>Cross referencing items either randomly or systematically demands new possibilities</p> <p>Sensory Activity to facilitating exploring the problem and subsequent possible solutions</p> <p>Using analogies and metaphors making associations that create more than the sum of two ideas</p>	<p>Removing inhibitors increasing participants' confidence to explore and try things when the outcomes are not always clear and they're conditioned to having to come up with the single 'right' answer</p>
Problem Delineation	<p>Intuition to understand the bigger picture</p> <p>Refining the problem</p> <p>Deconstructing the problem</p> <p>Mind mapping</p> <p>Storyboarding</p> <p>Using blog to refine thinking and reflect</p>	<p>SCAMPER – combining the deconstructed components in new ways</p> <p>Challenging assumptions to break patterns of behaviour and facilitating the unexpected</p> <p>Random Association to make connections between things even when they are not apparent</p>	<p>Using intuition as springboard for exploration</p> <p>Refining ideas through discovery</p> <p>Using intuition to question assumptions and refine thinking about the problem</p>	<p>Assessing components to identify "leverage points" and opportunities for new approaches</p>
Information Gathering	<p>Seeking information on the big picture and component parts</p>	<p>Considering multiple sources and then looking for springboards</p>	<p>Challenging assumptions to generate new ways of addressing the research</p>	<p>Combining findings from sources to help refine the solution or to</p>

	<p>guided by intuition and refinement of the problem</p> <p>Using blog to capture thoughts and document research findings</p> <p>Sharing findings via wiki and bookmarking sites</p>	<p>to new sources – forming new associations</p> <p>Modifying research strategy as ideas are refined</p> <p>Analysing information to identify priorities, possibilities and areas for further research</p>	<p>process</p> <p>Undertaking research using a variety of sources (Web, social media, library, databases, broadcast media, primary sources) and then refining research process</p> <p>Seeking different sources of information</p>	<p>generate new ideas to springboard further areas and sources for research</p>
Experimentation and Validation	<p>Using visionary techniques employed to generate and identify problem to come up with novel solutions</p> <p>Using blog to document experiments and reflect on the outcomes</p> <p>Collaborating via blog and discussion forum</p>	<p>Moving from divergent manipulations of information to convergent refinement to focus on practical solutions</p>	<p>Risk taking and making mistakes to explore possibilities without penalty if they don't work, leading to refinement and weighing up the solutions to arrive at practical solutions</p>	<p>Risk taking and making mistakes without penalty if they don't work, leading to refinement and weighing up the solutions to arrive at practical solutions</p> <p>Building on the solutions that have been shown to be more likely to lead to success</p>
Implementation	<p>'Prodsusage' using social media</p> <p>Discussion, peer review, use of web metrics and formal evaluation</p> <p>Personal blog for reflection on process</p> <p>Public blog for gaining feedback</p>	<p>Modifying approach if initial implementation needs further refinement</p>	<p>Exploring the unique contribution the innovation has made through market research and evaluation</p>	<p>Evaluating and examining success and identifying areas for future improvement.</p>

3.1.3 Trials of the CPS framework in a first-year undergraduate course

Introduction to Digital Media (IDM) is a first year undergraduate course offered in the School of Communication, International Studies and Languages at the University of South Australia. The aim of the course is to introduce students to the principles of digital media through a practice-led research approach. Prior attempts at engaging students in research had proved challenging (see Wood 2010; Wood & Bilsborow, 2013 for detailed discussion of the results of formal evaluations).

The three assignments in the course build on each other and are designed to lead students through a practice-based research approach involving researching the needs of a not-for-profit organisation and producing pre-production documentation for a short promotional video clip for that organisation as the second assignment. Students then produce an associated website in which the promotional clip is embedded as their final assignment.

In the 2009 and 2010 offerings of the course students were asked to formulate their research using a paper-based version of the CPS framework designed to guide them through the idea generation process. A range of social media tools were utilised in the course: an 'ideas journal' students maintained as a personal blog throughout the course; a wiki to facilitate brainstorming and to encourage collaborative discussion; a discussion forum for peer review; a collaborative bookmarking site for sharing resources; and a YouTube channel, for showcasing student work to a broader audience.

Several emergent themes from the application of CPS in this course (see also Wood 2010; Wood and Bilsborow 2013) were noted based on teachers' informal feedback and student course evaluations conducted at the completion of each offering of the course:

- Teachers reported much greater creativity and divergence in the approaches students adopted in their digital media research assignments.
- Students reported greater confidence in their ability to generate ideas for their research projects.
- Several students noted that CPS was critical to the success of their research.
- Most students enjoyed the collaboration with their peers and noted that the use of peer review facilitated via the discussion forum helped them to improve on their work.
- One student suggested that 'I thoroughly enjoyed this topic as it was highly creative and we were given a high degree of creative freedom despite having to work within the limitations set down'.
- Another commented 'The creativity component challenged my technical ability' and another reflected on the link between research and creative thinking, 'It was more research based and required a lot of creative thinking'.
- Creativity and problem solving developed through practice-led research was a commonly recurring theme in most student comments as this student's feedback indicates, 'Creative idea generation methods ... helped me to think very deeply and come up with alternative and sophisticated solutions to creative problems'.

Most students welcomed the brainstorming approach to idea generation implemented early in the course, however, two students commented that it was just 'mind mapping' and nothing particularly innovative; even though they acknowledged that the approach might be useful for 'other' students, 'It might work for some people but not so well for others. Only really suits a few types of learners'. Another challenge encountered in using the 'ideas' blog for scaffolding throughout the IDM course, was the tendency for some students to post their reflections to their blogs in the week 'in the flow' to maintain focus on the creative problem solving process throughout the duration of the semester.

3.1.4 Design of the CPS tool

The CPS framework therefore required considerable revisions over time, and as noted in the more detailed case studies reported elsewhere (see Wood 2010; Wood & Bilsborow 2013; Wood et al in press), the outcomes from each subsequent offering helped to improve on the approach throughout 2011.

An online tool (*Ingenium*) was designed in late 2011 based on the paper-based version of the CPS framework. This version of *Ingenium* incorporated the five stages of the CPS process with sub-sections comprising questions and prompts related to each of the five stages, which students access via arrows on each page (see Figure 2). Video clips were also included for each CPS stage to help guide students through the required tasks relevant to that stage. A pencil icon provided students with a link to a public blog site where they could set up and access their own blog account and another icon ('w') provides students with a link through to the project wiki. A menu was placed on the right-hand side of the interface providing students with a series of creativity tools including a 'notebook', 'toolbox' and 'resources' as well (see Figure 2). These sections included the social media and other supporting resources that the user might need throughout the creative solving process.

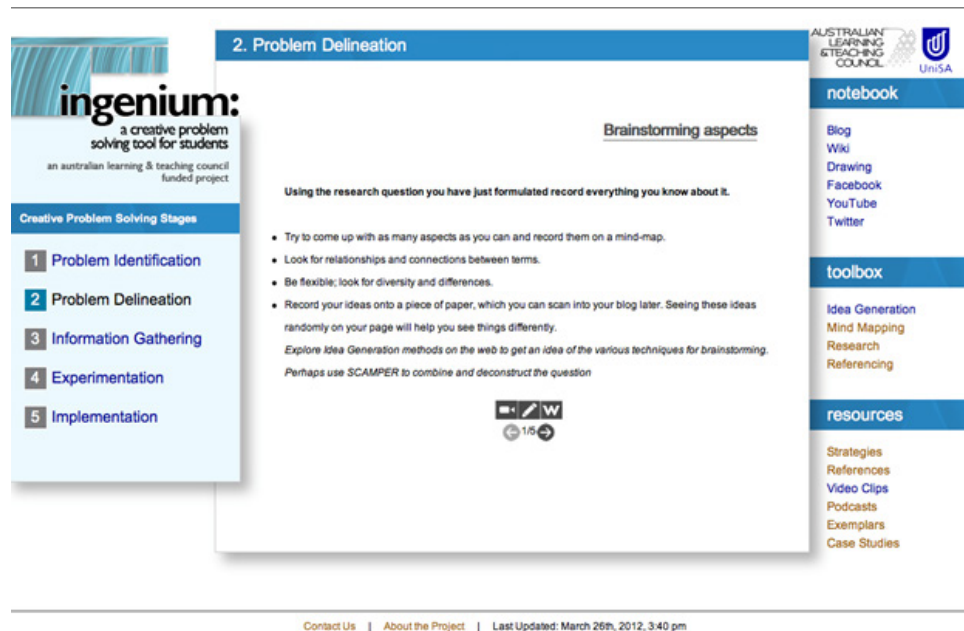


Figure 2: Design of first iteration of the CPS *Ingenium* tool

3.1.5 The redesign of *Ingenium* over successive iterations following a DBR approach

The DBR approach implemented in this study involved a research team comprising teachers, researchers and designers working in collaboration and the research approach employed mix-methods with multiple iterations involving designing, developing, trialling, evaluating, reflecting and redesigning informed by the previous iteration. The approach aimed to be consistent with the characteristics of DBR identified by The Design-Based Research Collective (2003) and follow the guidelines proposed by Reeves, Herrington and Oliver (2005). Details of the iterative cycles of design and redesign informed by the findings of a series of trial of the CPS tool over several offerings of the course are reported in detail in the following sections and also documented elsewhere (see for example Wood & Bilsborow, 2013; Wood et al, in press).

Preliminary trials of *Ingenium* were conducted in both semester one (Study Period 2; SP2) and semester two (Study Period 5; SP5) 2012. At the conclusion of the SP2 offering of the course, students were invited to complete the university's approved anonymous online course evaluation. The evaluation included three custom open-ended text questions: 1) *Did the creative problem solving process assist you in generating ideas for your topic and production?* 2) *Did you find the blog a useful approach to maintaining your journal of creative thinking and research?* 3) *What were your experiences using the creativity tool to generate your ideas?*

Of the 250 students enrolled in the course, only 19 (7.6%) completed the online evaluation and even fewer responded to the open-ended questions. Nevertheless, student feedback combined with teachers' observations and reflections on the experience did provide insight into the potential benefits and challenges in applying the tool in this first year course. Positive comments suggested that the course encouraged students to explore creativity in ways that they had not experienced in courses with more traditional assignments. Comments such as the statement by one student that 'It was a good course to express creativity through a different format, one that was more interesting than just the regular essay writing in others', and another who stated that 'it helped to clarify the idea I had' suggest that the approach had the desired impact. However, several students approached the task with a more closed mind and did not engage in the creative problem solving task as indicated by comments such as 'No, everyone already had their ideas to start with and in doing this did not further develop them or create them'. Some students also expressed frustration with the repetitive nature of the process indicating that the tool had not adequately reinforced the value of creativity occurring through a process of multiple iterations involving research, design, testing, refinement, collaboration and reflection.

Ingenium was trialled again in the same course in SP5 2012. At the conclusion of this offering of the course, students were again invited to complete the same anonymous online survey. Twenty-seven students responded and of those, 48% reported that *Ingenium* raised their awareness of creative problem solving and helped them to think more creatively about their assignment; 41% indicated that they felt *Ingenium* would be useful to other areas of their studies; and 33% of students reported that they felt more confident about their creative skills after using the *Ingenium*.

While one student 'Found the tool a great catalyst for new directions in thinking ...' and another reported that it was a 'Very good planning tool', others were challenged by the presentation of the interface as suggested by one student who commented 'I found the site rather hard to use. It was hard to follow the layout of the information and contained a lot of writing that could be cut down to be more accessible and concise'. Students were also challenged by the amount of time it took to complete the process, as comments such as 'The principles and techniques are good, but the presentation and long winded nature make it unusable' and 'Thought it was very useable it was also slightly daunting because of the amount of subsections ... this is incredibly tedious to work through' suggest. When asked what improvements should be made to the tool students suggested: 'Better structural layout'; 'Include some visuals ...'; '... perhaps find another way of presenting'; 'It needs a complete overhaul design wise'.

Based on the feedback from two semesters of trials in IDM in 2012, *Ingenium* was redesigned to include new video examples and text-based instructions (see Figure 3). During the SP5 2012 trial, one teacher observed that students were not using the example videos noting 'The students would begin playing the video and only watch it for a few seconds before closing it'. To address this issue, the 'talking-head' videos were replaced with short animations, designed to explain the stages of *Ingenium* in a more engaging manner.

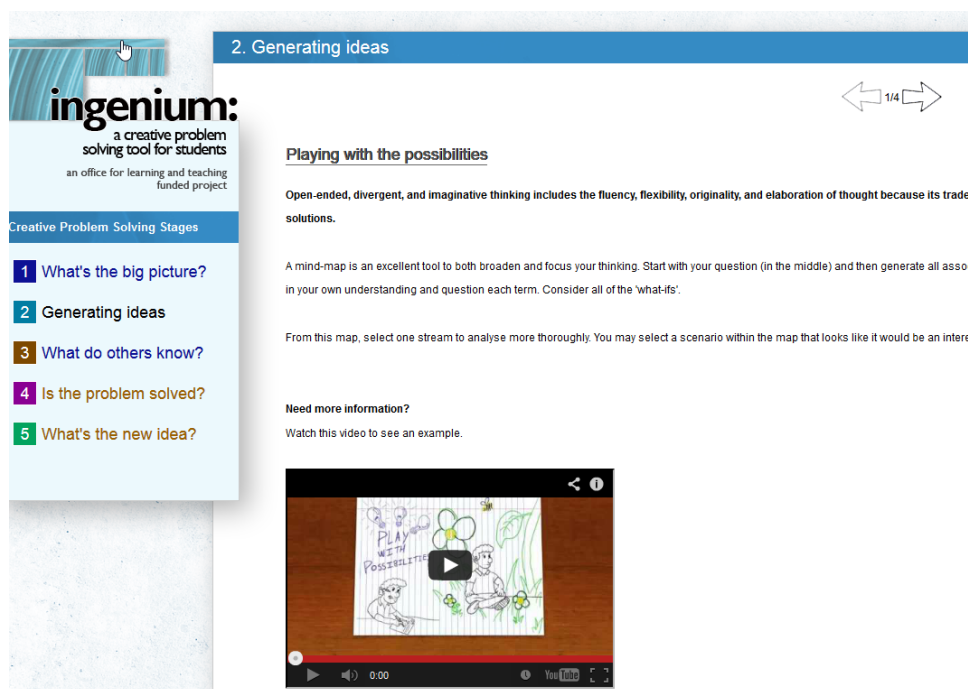


Figure 3: Redesign CPS tool with embedded video examples

The text component of the tool was also redesigned during this version in response to student feedback suggesting that the language used was too abstract and not descriptive of the process. For example, 'Problem Delineation' was changed to 'What's the big picture?' The procedural text descriptions were also simplified to address student feedback suggesting that the steps were too repetitive and long-winded.

The structure of *Ingenium* was also redesigned as a mind map (Figure 4) to provide a more creative, non-linear approach to the structure.

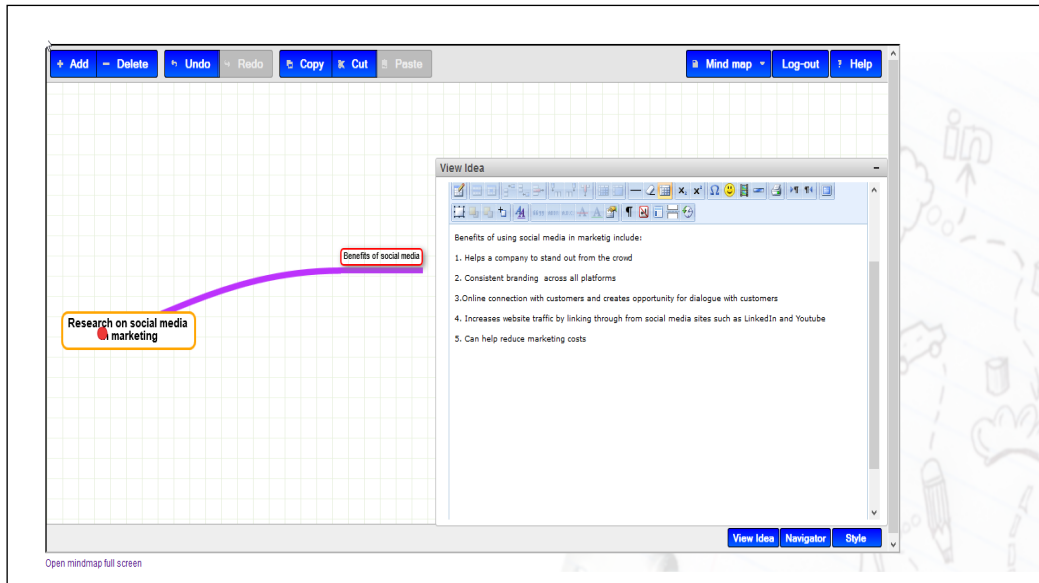


Figure 4: Redesign CPS tool with mind map interface

A new group of students enrolled in IDM undertook the same assignment to create the pre-production for a promotional video clip in the first semester (SP2) 2013. The students were encouraged to use the new mind mapping tool that would allow them to access the process in a non-linear fashion, but during the trial, technical issues with the mind mapping tool were encountered and many of the students were forced to return to the original linear, step by step instruction approach.

Sixty-two students responded to the online survey and their responses indicated an increase in the percentage of students who indicated that their awareness of creative problem solving had been improved through using the tool (48% in SP5 2012 to 55% in SP2 2013). Fifty-one percent of students reported that the tool had helped them think creatively compared with 48% during the previous trial, and 33% of students reported that they felt more confident about their creative skills after using the *Ingenium*, which remained the same as during the previous trial

Many students responded favourably to the redesigned video examples with comments such as 'The YouTube videos linked to the pages were useful' and one teacher observed that unlike the previous trials, more students watched the videos in their entirety. However, several issues were encountered by the students as reflected by comments such as: 'The mind map ... is a useful tool, but very unreliable'; 'I liked how *Ingenium* was easy to use, however, I was not pleased with my mind map being entirely deleted days before my assignment was due'; and 'it would have been wicked, but it crashed a lot'. When asked what improvements should be made to the tool students reported that 'the menu structure should be made more easy to understand'; 'it just needs to be fine-tuned so that the questions are less repetitive and the mind-mapping section works'; and 'work primarily on the user interface and the rest will come, as will interest'.

The student feedback from the three trials of *Ingenium* reported in the previous sections informed the next iteration of the design and development cycle. The major revisions included a move to a more robust approach to coding the site to avoid cross-browser issues, the redesign of the entire interface as a mind map with engaging graphics representing each stage of the CPS and each sub-section (Figure 5).

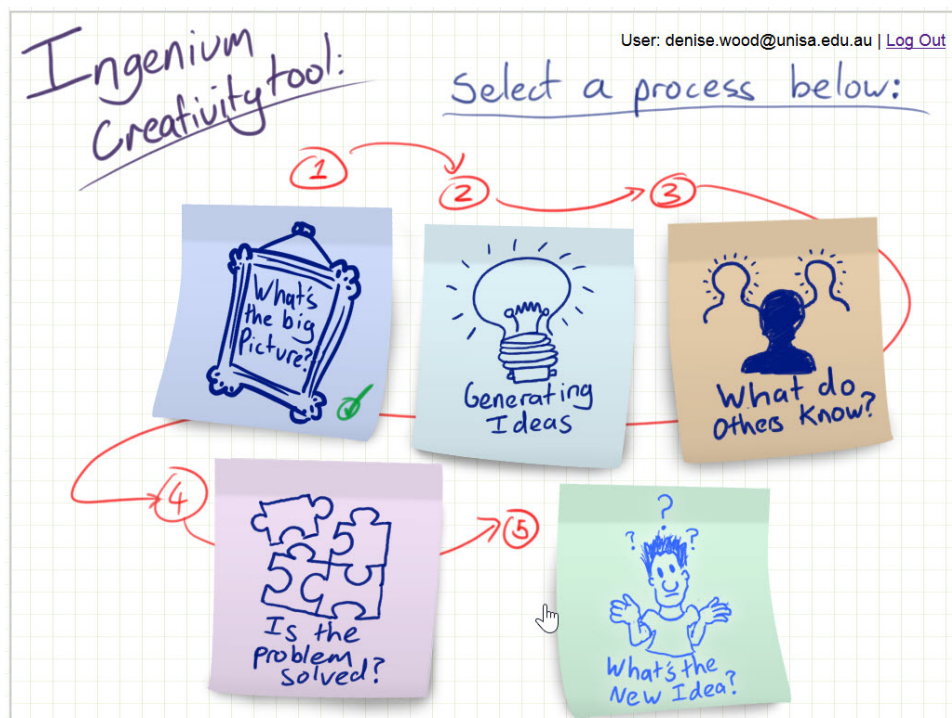


Figure 5: Revised *Ingenium* mind mapping tool

Students interact with each of the 'post-it' note image links to progress to sub-sections of each CPS stage and can embed their thoughts, research, images and links within the clouds relating to each sub-section. A toolbar above *Ingenium* provides students with the ability to navigate back and forth in a linear or non-linear approach as they work through the CPS stages. Students can also print out a report of their progress in outline format (Figure 6).

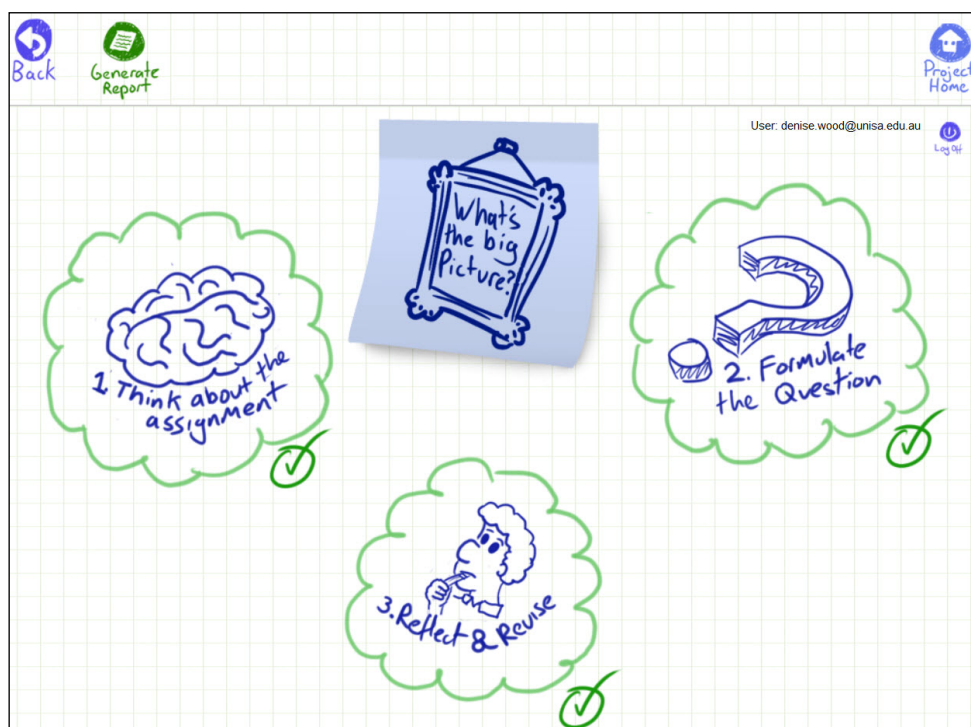


Figure 6: Revised *Ingenium* with report generator button

The revised *Ingenium* tool was trialled during the SP5, 2013 offering of IDM. Eight students responded to the online survey after completing their first assignment using the tool. Once again, there was diversity in experiences reported. Some students enjoyed the process as reflected by comments such as, 'it enabled me to think outside the box in relation to my topic and brought forward some really valuable ideas' and 'I liked *Ingenium* as I am not a person with a creative mind'. But several students noted there were too many repetitive steps involved as indicated by comments suggesting 'I liked the way that it stepped through each stage, but I believe the number of steps needed to complete was time consuming'. Similarly, one student stated that 'there are too many sections which means you are constantly repeating yourself, also it is not clear what to put in each section' and another suggested that 'a danger was to spend far too much time filling in the various boxes/bubbles. It could very easily eat up time'.

Beyond the mechanics of the tool students reflected on how *Ingenium* allowed them to combine the processes of research and creativity. One student reported, 'I found it interesting that we were asked to brainstorm, write down assumptions and deconstruct/reconstruct first then to do further research. Usually it is the other way around. I liked this approach as I didn't have any pre conceived ideas or restrictions influencing my ideas, I do wonder how my ideas would have differed if I had researched first'. Often considered as two distinct stages, research and creative problem solving are brought together in this tool, enabling students to see the complementarity of the processes.

The feedback from many iterations of the DBR process indicates that there are still some issues to be resolved, particularly with respect to the repetitive nature of the steps. Based on the findings of these trials, further revisions are in progress reduce the requirement for students to complete reflective notes at the completion of each sub-section within the major stages of the CPS process. Rather, they will complete the sub-sections and then summarise their reflections for that stage of the process before moving on to the next stage. This revision will allow users to skip over the sub-steps that they feel are unnecessary. The revised version of *Ingenium* will be trialled in IDM during the first semester of 2014 and reported in future publications.

3.1.6 Design of guidelines informed by the findings

As noted in the preceding sections, an important feature of DBR is that the research results in the development of guidelines for use by other teachers. The guidelines arising from this study are documented in detail in the final report (Wood et al, in press), and include guidelines for planning to teach creative problem solving, strategies for teaching creative problem solving, and appropriate alternative approaches to assessing creativity. A brief summary of the guidelines follows:

Planning to teach creative problem solving: This set of guidelines acknowledges that changing to a new teaching method takes flexibility and practice, and a commitment to transforming the teaching and learning approach from teacher-centred to student-centred. The approach highlights the benefits of engaging students in activities in which they learn by design recognising that graduates need skills that enable them to respond to complexity and uncertainty in the workplace, and that skills require a level of tacit knowing and confidence that cannot be acquired from reading through the process alone.

Teaching creative problem solving: These guidelines emphasise the importance of teaching the value of creativity, valuing exploration and mistakes, building on students' interests, enhancing opportunities for student collaboration, and embedding reflective practice in the curriculum.

Assessing creativity: Many teachers are unsure of how to assess creativity; however, alternative assessment approaches such as self- and peer-assessment are well suited as they encourage reflection and collaboration. Another important feature of assessing creativity is to focus on the process, rather than the end product; rewarding students for experimentation and learning from their mistakes through critical reflection on the process and acting on what they learn through the journey is in many ways more important than the final product arising from that process.

4. Conclusion

The study reported in this paper aimed to address the three major challenges affecting the capacity of teachers to incorporate creative problem solving approaches into their teaching and learning. These three challenges include the lack of an appropriate model to support them in making the required shift from

outmoded pedagogical methodologies to more creative approaches; the lack of a concise definition of creativity within policy documentation; and the lack of strategies to help teachers develop the skills to engage with creativity in their teaching and learning. The study involved developing a CPS framework and associated tools designed to scaffold students through the creative problem solving process and guide teachers in the design and redevelopment of the curriculum.

The DBR approach applied in the project ensured that the development of the CPS tools was responsive to student and teacher feedback through multiple iterations involving design, development, trials, evaluation, collaboration, reflection and revision. Consistent with a DBR approach, the research built on a strong theoretical foundation informed by creativity theories and contemporary research showing the benefits of creative problem solving in education (Amabile 1996; Robinson 2001; Titus 2006; Tosey 2000) and practical techniques to guide teachers, and support students undertaking creative problem solving activities (Titus 2000; The Global Creativity Corporation). The DBR approach is not without its challenges (see for example Anderson and Shattuck 2012; Barab and Squire 2004), as the highly critical feedback by students to early iterations suggest. However, the approach is appropriate for research that seeks to address 'real-world' problems through an iterative research process, which systematically refines the design, while also leading to the production of design principles and practical guidelines (Amiel and Reeves 2008: 34).

The study also highlights the value in students being integrally involved in the design and development of technology enhanced learning innovations. As the feedback documented in the preceding sections demonstrate, without such rich formative feedback, it would not have been possible to develop a CPS tool that meets the needs of students from diverse backgrounds. Moreover, as we came to realise when students started using the tool in their assignments, the DBR approach reflects the approach students themselves are undertaking in their assignments through the design based learning approach employed in the course. Therefore, an unintended benefit from the adoption of DBR as our preferred research design has been the enhancement of our understanding of the similarities between DBR as a research approach and design based learning, which in turn, is reflected in the final design of the CPS tool. As Vogt et al (2010) suggest, 'learning by designing' can facilitate deep learning and competence development through a complex series of activities involving students in the process of information gathering, problem identification and constraint setting, idea generation, modelling and prototyping, building, and evaluating.

The focus of this paper has been on the application of DBR to the design and development of a CPS framework and tool to support students. Although only one case study (a first-year undergraduate course) is reported in this paper, the same process has been applied in the trials of all 10 courses that were included in the study. Furthermore, this paper only reports the findings from trials of the CPS tool with students, even though the aim of the project was to design and develop a framework and tools to both scaffold teachers in the design of their courses and guide students in the application of creative problem solving within their courses. Research involving trials of the CPS tool with teachers are currently underway to assess the extent to which the framework and tool is effective in facilitating the kind of transformation in teaching practice required to support teachers in engaging with creativity 'intentionally as an outcome of pedagogical work' (McWilliam 2007a, p. 4).

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