Analysis of Usage for Two Digital Format Ideation Templates

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SESSION S2: EDUCATING THE EDISONS OF THE 21ST CENTURY

CONTEXT It has been reported that current teaching methods may lead to a significant decrease in students' creativity skills over the four years taken to complete an engineering degree. One reported approach of increasing creativity performance is exposure to suitable idea generation heuristics (Belski, Hourani, Valentine, & Belski, 2014). Research has demonstrated that students are able to apply suitable idea generation heuristics equally effectively using either a pen-and-paper or computer based approach, and that learning the heuristic using either platform leads to measurable enhancements in long-term performance (Valentine, Belski, & Hamilton, 2016). Website-based idea generation activities would requiring web browser software for usage, and the potential for enhanced interactivity, which can enhance engagement. But even simple websites generally take more time, effort and resources to make than other digital formats, such as Portable Document Format (PDF) files.

PURPOSE To establish whether students (in a *voluntary* setting) are more likely to use a website or PDF version of an idea generation template (similar in layout and content), when provided with the option to use either, or both. This will help to establish whether it is worthwhile to expend resources developing website-based versions in the interest of encouraging student usage of the learning resources in a voluntary setting, instead of PDF versions that generally take fewer resources to construct than website versions.

APPROACH Two idea generation heuristics were selected and learning resources were created for each heuristic; instructional video showing how to apply the heuristic, along with a website format template and similar PDF format template that each guided a person through the process of applying the heuristic. These resources were placed within a website that had been designed for the distribution of creativity related heuristics and techniques, which students were able to voluntarily make use of for self-directed study. A database was used to record the date and time each time either the website or PDF template for either heuristic was accessed over a period of twenty six weeks. Entries were collated into the appropriate week in which they occurred, and analysis was conducted to establish whether students were more likely to access one format of template than the other on average during a week.

RESULTS For the first heuristic, students accessed the website version at a ratio of 1.52 times more often than the comparable PDF version, and the difference was statistically significant. For the second heuristic, students accessed the website version at a ratio of 1.39 times more often than the PDF version, but the difference was not statistically significant.

CONCLUSIONS Overall, the findings may suggest that the uptake rate of digital-based idea generation activities in a *voluntary* usage setting may be higher if website versions of templates are provided rather than PDF versions, although this cannot be stated with certainty. Educators may therefore be inclined to dedicate resources to developing and hosting website versions, in the interest of maximising usage of provided learning resources by students. However, this study has not investigated whether usage of one digital format over the other lead to differences in apparent learning gains, which would also be important for educators to know before adopting such a decision.

KEYWORDS Ideation, digital format, usage statistics

Introduction

The need for creativity

The ability to demonstrate a creative and innovative demeanour is one of the expected traits of professional engineers (Engineers Australia, 2011). Research has demonstrated that fourth year undergraduate engineering students perceived themselves to be significantly more innovative than first year undergraduate engineering students (Davis & Amelink, 2016), suggesting that studying an engineering degree leads to an increase in students' confidence in their ability to be innovative and successfully build related skills. However, it is apparent that students' perceptions may not accurately reflect measured results. It has been reported that the problem-solving self-efficacy of students actually declines over the four years taken to complete an engineering degree (Steiner et al., 2011). Genco, Hölttä-Otto, and Seepersad (2012) investigated the innovative capabilities of first year and fourth year engineering students when solving a specified open-ended design problem. The overall findings suggested that fourth year students were less innovative than their first year counterparts. Other research has reported a concerning finding that the measured creativity levels of fourth year engineering students were significantly lower than that of their first year counterparts, although critical thinking was similar was measured to be similar (Sola, Hoekstra, Fiore, & McCauley, 2017), This may unfortunately suggest that some students' creativity actually decreased during the four years taken to complete an engineering degree. This is concerning as innovation requires the ability to generate ideas which can be considered as original or creative, that are also applicable in a practical manner to a real problem (Amabile, Conti, Coon, Lazenby, & Herron, 1996). When these outcomes are considered together, the conclusions are disconcerting. It is apparent that while students consider themselves as more innovative as a result of studying an engineering degree, research findings show that there is a disconnect between students' perspectives and their measured performance.

Inclusion of explicit (i.e. clearly stated in the learning outcomes) creativity related material within engineering curricula is relatively uncommon (Daly, Mosyjowski, & Seifert, 2014; Marquis, Radan, & Liu, 2017). It is asserted that where creativity related material is covered within curricula, it is typically covered through the introduction of idea generation (ideation) techniques or heuristics as part of a class on design (Genco et al., 2012). Finding ways to overcome the current lack of creativity related material is a challenge faced by many educators who deal with an already full curriculum.

Educators who have previously introduced courses that focus on the development of creativity and problem solving skills have reported benefits of enhanced creativity performance (Anderson, 2006; Chang, Chien, Yu, Chu, & Chen, 2016; Mahboub, Portillo, Liu, & Chandraratna, 2004). Considering creativity training on a larger scale, meta-reviews have concluded that creativity training (such as use of ideation techniques) is generally an effective means of enhancing the creativity of training participants, although it can depend on the context under which training is conducted (Scott, Leritz, & Mumford, 2004; Tsai, 2013).

An experiment conducted by Belski et al. (2014) investigated the influence of ideation techniques on first year engineering students in an ideation task of 15 minutes duration. It was found that exposing students to techniques resulted in significantly improved idea generation performance, leading to the suggestion that short, self-contained ideation activities may be included in courses throughout an engineering degree as a means of enhancing the creativity of students. Follow up research concluded that providing creativity training on the application of an ideation heuristic via a 10 minute instructional video and subsequent involvement in a 15 minute ideation task, lead to a measurable enhancement to participants' ideation performance even after a period of three months (Valentine et al., 2016). Furthermore, it was established that students were able to effectively perform in the initial ideation task using either a pen-and-paper or computer-based template, and that the platform which students used during the initial task had no influence on the long-term

performance of participants. It was therefore concluded that web-based ideation tools may be a suitable means of providing students with opportunities to enhance their creativity skills, while having the benefit that students may access and make use of them at any time, and that educators may provide this access without requiring the use of dedicated class time.

Digital-based ideation activities: in which format?

A significant dilemma to this conclusion is that websites generally take significant time, effort, and resources to develop and host. This raises the question of whether it is worthwhile to expend resources to develop web-based tools which guide a user through the process of applying a specified ideation technique, when students may instead make use of a digital format template which takes fewer resources to develop, such as PDF (Portable Document Format). Students may potentially make higher usage of digital-based ideation activities if they are website-based, though this is unclear. However, this would lead to a disadvantageous situation for educators who would need to spend more time, effort and resources to construct the required learning materials.

There is a current lack of studies in the available literature which have attempted to investigate the usage rates or preferences of students when provided with two digital format ideation template alternatives. Many studies that compare the actual usage (or access) rates of two formats that present identical content using the same layout, are library based studies which have investigated the usage rates of print books compared to their equivalent same-title electronic-book formats (Christianson & Aucoin, 2005; Morgan, 2010; Ramirez & Tabacaru, 2015; Taylor, 2013). Literature comparing digital-based formats is relatively limited in the literature. Pettifer et al. (2011) compared the theoretical advantage and disadvantage perspectives of representing academic articles in different digital formats such as PDF and websites, finding that each format has different benefits or drawbacks depending on the context, such as storage, human tasks (such as reading) or machine task (such as searching for text). Other literature reports findings of participants' usage preferences. A survey of 281 academics conducted by Elsevier investigated which format academics preferred for research related purposes, establishing that academics considered PDF to be preferable for in-depth reading, but website format to be preferable for searching for information due to convenience (Aalbersberg, 2013). A related study of 184 undergraduate students conducted by Schierhorn, Wearden, Schierhorn, Tabar, and Andrews (1999) found that when provided with the choice of reading a traditional print newspaper or a digital newspaper using either website or Portable Document Viewer (PDV) formats, participants demonstrated an overall statistically significant ($p < 0.05$) preference for digital items in the PDV, rather than website format. Although these studies provide insightful research findings, it is difficult to accurately infer which format of ideation templates students may be more likely to utilise or preference.

The aim of this study is to investigate students' access rates of two digital-based ideation templates that are presented in different formats (PDF and website), when presented with the *voluntary* opportunity to utilise either (or both) for use in self-directed study. Understanding which format of digital-based template is more heavily accessed will help educators to understand whether it is worth investing time, effort and resources in the development of website-based ideation templates in this context, or if it is suitable to provide templates that take fewer resources to develop and host, such as PDF.

Methodology

Ideation Techniques

To compare usage rates of two digital format ideation templates, appropriate templates first needed to be created. For this, selection of an appropriate ideation technique upon which to base the templates was required. The website- and PDF-based templates were required to be designed in order to guide a person through applying the technique with minimal external

instruction. To check for repeatability, it was selected that two ideation techniques would be utilised and a website- and PDF-based template would be created for each.

The Fields of MATCEMIB (Mechanical, Acoustic, Thermal, Chemical, Electric, Magnetic, Intermolecular, Biological) is a TRIZ (Russian: teoriya resheniya izobretatelskikh zadach, English: theory of inventive problem solving) based problem-solving methodology that is primarily designed to find solution ideas to problems of a technical nature. The technique has repeatedly been shown to enhance the ideation performance of engineering students relative to a control group provided with no external guidance (Belski et al., 2015). Moreover, it has been demonstrated that exposure to the Fields of MATCEMIB technique and subsequent engagement in an ideation task of 15 minutes duration lead to measurable improvement in ideation performance even after a period of three months (Valentine et al., 2016). Therefore, this technique was selected as one of the two ideation techniques for which digital-based templates would be created.

The Fields of MATCEMIB technique requires relevant domain knowledge to apply the technique most effectively. Therefore, it was nominated that the second technique be more widely applicable to a wider range of problem types, not take much time to learn, and not require specific domain knowledge. Size-Time-Cost Operator is a TRIZ ideation technique (Gadd, 2011, p. 18) which meets these criteria (Belski, 2015), and was accordingly chosen as the second technique for which digital-based templates would be created.

Digital-Based Templates

PDF templates were first created for both of the two ideation techniques. The templates consisted of several steps appropriate for the ideation technique. For each technique, the template guided the user to first set up the scenario of interest in the manner appropriate for the technique. Once all necessary information was provided, the templates guided the user to generate ideas to resolve the problem. Both the Fields of MATCEMIB and Size-Time-Cost Operator techniques do this by systematically repetitive means. Each technique forces the user to focus on and consider one distinct concept at a time, which has been asserted to improve ideation performance as it means that a person is less likely to try and simultaneously consider several potential solution ideas (Belski & Belski, 2008). A separate prompt and space to write ideas was provided for each of the distinct concepts a person must consider when implementing each technique. The Fields of MATCEMIB asks a person to consider eight distinct concepts for generating ideas (the fields of Mechanical, Acoustic, Thermal, Chemical, Electric, Magnetic, Intermolecular, Biological) (Belski, 2007), therefore these templates included eight applicable prompts and space to write ideas underneath, displayed on the template one after another. Likewise, the Size-Time-Cost Operator asks a person to consider six distinct scenario for generating ideas (when available Size, Time, and Cost are zero or infinite) (Gadd, 2011, p. 18) and the applicable prompts were presented sequentially and with space to write ideas underneath.

Once the PDF templates were created, a website-based version of each was created. The website versions were designed to have a similar layout to the PDF versions. Each website template contained several webpages which the user was able to sequentially navigate through, and logically segmented the information contained within the PDF versions into appropriate webpages. Alongside the digital-based templates, an instructional video of approximately 10 minutes duration that explained to students how the appropriate heuristic, was created for each of the two heuristics.

An index webpage was then created for each heuristic. Each index webpage contained links to the three resources applicable for each heuristic; the instructional video, the PDF template, and the website template. Both of the index webpages, videos, PDF templates and website templates were then placed within a repository website that had been specifically designed for distribution of creativity related heuristics and techniques, that students would

be able to voluntarily make use of in self-directed study in order to enhance their creativity when solving open-ended or ill-defined problems that formed part of their coursework.

Data Collection

In order to assess the rate at which students accessed one type of digital-based template compared to the other, a database was set up to record an entry every time a student independently accessed the website or PDF template for either heuristic. Each entry recorded the date and time of the resource access.

At the beginning of a university semester, the repository was promoted to engineering students of some Australian and New Zealand universities through the Engineers Without Borders association and the Golden Key International Honour Society. Engineering educators at these universities, especially those teaching courses on engineering design or participating in the Engineers Without Borders Challenge, were requested to inform their students regarding the availability of the repository and briefly discuss potential benefits of utilising creativity heuristics within their projects. Due to the nature of promotion of the repository and voluntary usage of its' contents by educators and students, it was not possible to fully control the extent to which educators promoted the repository within their classes, or accurately predict exactly how many students the repository was promoted to. This is a limitation of the study, and results may therefore be different if students were required to use the repository for their projects. Educators and students were again provided with the information after a period of eight weeks. The creativity heuristic resources were made available to students to voluntarily use in self-directed study for a period of 26 weeks, and the access rate of each template style for both heuristics was recorded over this period of time.

Data Analysis

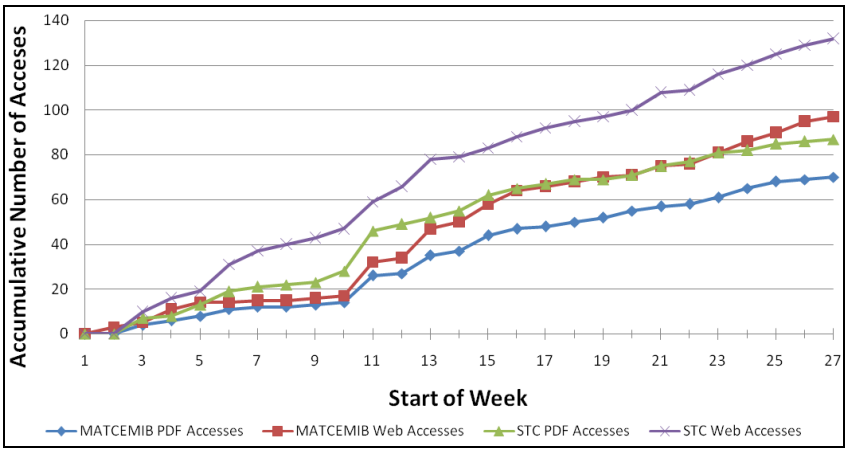

Figure 1: Accumulative of Times Each Resource Accessed over 26 week period

After the period of 26 weeks had concluded, the data was analysed. The data was evaluated and categorised according the week in which the database entry had been created. This allowed observation of how many students had accessed each template during each of the 26 available weeks. The accumulated number of times that each template had been accessed at the start of each week can be observed in Figure 1. Analysis showed that there were a relatively high number of template accesses in week 10, compared to other weeks. Each resource type was accessed at least 12 times during week 10. The Fields of MATCEMIB web tool was accessed 13 times during week 12, and the Size-Time-Cost Operator web tool was accessed 10, 12 and 12 times in Weeks 2, 5 and 12, respectively. These relatively high usage values may reflect weeks where academics may have informed students about the availabilities of the self-directed learning resources, creating a higher uptake by students in their respective courses.

Results

Analysis showed that students used the Fields of MATCEMIB PDF template a total of 70 times during the 26 weeks (M: 2.69, SD: 2.66), while they used the Fields of MATCEMIB website template a total of 97 times (M: 3.73, SD: 3.64); a ratio of 1.39 website utilisations for each PDF utilisation. Students used the Size-Time-Cost Operator website a total of 87 times during the 26 weeks (M: 3.35, SD: 3.58), and used the PDF template 132 times (M: 5.08, SD: 3.38); a ratio of 1.52 website utilisations for each PDF utilisation. The access data for all four templates were not normally distributed according to the results of the Shapiro-Wilk test of normality; therefore the non-parametric Mann-Whitney U Test was used to check for statistical significance between groups. Results of the Mann-Whitney U Test showed that there was statistical significance between usage rates of the Size-Time-Cost Operator template formats ($Z=-2.318$, $p=0.020$), but not between usage rates of the Fields of MATCEMIB template formats.

It can be observed in that the standard deviation for the usage rate of several templates was quite large compared to the mean. This is likely caused by the unusually high access rates of templates during certain weeks, as previously discussed. It was therefore decided to re-conduct analysis with outliers removed to see if this resulted in any change to the statistical significances. Removal of outliers resulted in the Size-Time-Cost Operator website version being accessed a total of 43 times (M: 1.87, SD: 1.14), and the PDF version a total of 69 times (M: 2.88, SD: 2.09), respectively. The Fields of MATCEMIB website version was accessed a total of 69 times (M: 2.76, SD: 2.01), and the PDF version a total of 132 times (M: 5.08, SD: 3.38), respectively. Evaluation showed that after removing appropriate outlier values from each group, statistical significance between Size-Time-Cost Operator template access rates remained, while the lack of statistical significance between Fields of MATCEMIB template access rates also remained. In other words, removing outliers from each group did not change the results.

Discussion

The results of this study have demonstrated that when provided with the opportunity to make use of either website- or PDF-based ideation templates that are equivalent in content and similar in design layout in a *voluntary* manner, students may be more likely to access the website-based version, although this cannot be stated with certainty. It was evaluated that students accessed the Size-Time-Cost Operator website ideation template significantly more often on average per week than the PDF template, with the website version being used at a rate of 1.52 times that of the PDF version. However, this finding was not repeatable for template access rates for the Fields of MATCEMIB heuristic. Although students accessed the Fields of MATCEMIB website template at a rate of 1.39 times that of the PDF template, the difference in mean number of weekly accesses by students was statistically insignificant.

It is difficult to directly compare the findings of this study to that of existing literature, as existing studies either compare actual usage rates of print and equivalent electronic book formats, or compare the preferences people have between two digital-based formats that are being used in very different contexts to this study (such as academic research or newspaper reading). Previous research has found that people significantly preferred to read and access newspapers using a Portable Document Viewer format over a website format (Schierhorn et al., 1999), while this study found that participants accessed the website version at a higher rate. As the participants of this study and the study by Schierhorn et al. (1999) were both of similar age groups, this suggests that the usage rates or preferences that people are likely to show between two digital-based formats, may be highly dependent on the context or activity.

These outcomes suggest that there may be merit in the notion that educators may seek to develop digital-based ideation templates that are website based for use in *voluntary* settings. Although the mean weekly usage rate of Fields of MATCEMIB web template was not significantly higher than the PDF template, the usage ratio suggests students still suggests a

slight preference for the website templates. Educators may consider how these findings may assist them to engage students with ideation style learning activities in a voluntary context. As students have already demonstrated a potential slight preference for website based ideation templates in a voluntary setting, educators may use this to their advantage in the interest of encouraging higher usage of the learning resources. Software which has increased levels of interactivity is likely to encourage students to use the software, especially where the software can be considered fun to use (Cavallucci & Oget, 2013). It may be reasoned that if educators were to develop website-based ideation activities with high levels of appropriate interactive features (as opposed to being akin to a static worksheet), and make students aware of these interactive features, students may be further inclined to make use of ideation learning materials that are provided for them to use in a voluntary setting. In turn, this may help to enhance their creativity skills and help to at least in part overcome the decline in creativity and innovation skills that has been reported to occur over the four years taken to study an engineering degree (Genco et al., 2012; Sola et al., 2017).

It is important to consider the limitations of this study. It is required to emphasise that this study did not aim to address whether students may make more effective use of ideation templates when they are in PDF or website format, but aimed to provide a foundation for understanding whether students show a preference for one format or the other in a *voluntary* setting. While it is reasonable to assert that students may simply use the format that is provided if no choice it offered, and that there may not be reason for educators to consider website format over PDF format, it is important to reflect on the voluntary usage of learning resources that aimed to be addressed in this study. It is likely that students will make use of a voluntary learning resource at a higher rate, when it suits their preference of format. Students may show a different preference of format if they are *required* to use the learning resource. The consideration of whether one format may be more beneficial to students than the other in a voluntary setting, and whether students may prefer one format over the other in a setting where they are required to use the resources was outside the scope of this study and is a possible direction for future research. Future research may investigate whether these findings are repeatable in a setting where students are expected to use the resources. Qualitative measures may also provide insight into the potential benefits or disadvantages of using templates, or engaging in activities, that use one digital format or another.

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