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Preparing IT Professionals for the Knowledge Economy

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ABSTRACT

This paper reports the results of an empirical examination of a learning tool aimed at stimulating creative and innovative performance of IT students. The tool is based on a brainstorming method that provides students with external stimuli and exposes them to a large number of ideas over a short period of time. An empirical test was conducted using students from a software development course. The results of this study indicate that application of the tool significantly improves participants' creative performance. In particular, interaction with the tool resulted in a significant increase in the originality of ideas generated without affecting their relevance and workability.

INTRODUCTION

Organisations operating in a knowledge-based economy are facing new challenges. To remain competitive in an era of increasing uncertainty and market globalisation they must constantly be creative and innovative with their products and services. Software has been widely considered as central to all sophisticated innovations [12]. In many of the fastest growing industries, including computer, entertainment, communications, advertising, logistics and finance, software has been the end product itself, or the highest value component in the end product. In other cases, software has been used to support value creation and innovation processes.

The growing importance of software-based innovations suggests the need for improving the creative skills of IT professionals. This need, in turn, requires an appropriate response from the IT education and training sector. It is argued here that IT education and training should better nurture students' creativity, so that they can be successful in their future roles as innovative professionals and business people. It is particularly important that IT students be given an opportunity to develop and apply creative and innovative skills to software processes and products.

Given the crucial importance of creativity and innovativeness for success in a knowledge economy, the main purpose of this study is to address this issue in the context of IT education. In particular, this study will propose and investigate the effectiveness of a specific learning tool aimed at enhancing creative thinking and idea generation of IT students enrolled in software development courses.

LITERATURE REVIEW

Creativity has been defined as the production of novel and appropriate ideas, solutions and work processes [15]. While uniqueness and novelty are the key dimensions of creative expressions, appropriateness is also an essential requirement in the context of problem solving and innovation. There is no single unifying theory of creativity. The literature suggests a number of different perspectives [9]. The psychoanalytical perspective views creativity as a preconscious mental activity. It proposes that creative thinking occurs in our subconscious thoughts and is not directly accessible to our conscious thoughts. The behavioural perspective considers creativity as a natural response to stimuli within our individual environments and suggests that certain combinations of stimuli can lead to more creative behaviour than others. The process orientation perspective sees creativity as a property of a thought process that can be acquired and improved through instruction and practice.

Consistent with the view that creativity can be acquired through instruction and practice, a number of techniques have been developed to stimulate creative idea generation. Brainstorming, for example, is a technique that uncovers ideas without being constrained. External factors are used to stimulate ideas generation. The method allows individuals or groups to capture their thoughts [14]. Mind mapping is another method that involves recording of the free flow of ideas by drawing up a map that iterates your ideas [19]. A variety of technologies have been developed that follow specific creative techniques (*e.g.* Ideafisher, Mindlink, IdeaPro, *etc*) to facilitate "out of the box" thinking [17].

Most findings from past empirical studies indicate that creative performance is highly contingent upon a variety of environmental, cognitive, technological and other various factors. Variables that produced different degrees of creativity included problem importance, common perspectives, familiarity with possible solutions, trust, flexibility of process, external forces and feedback [7]. The optimal condition for high creativity involves working alone with no expectation of evaluation [15]. In addition, being given creative examples and informational feedback also improved creative performance [16]. Computer-assisted brainstorming led to better performance in some studies [11].

Building on research reported earlier in this section, the current study focuses on studying individual creativity supported by a learning tool based on a brainstorming technique. The primary objective of the study is to: i) describe the learning tool as a potentially valuable means for stimulating creative thinking and idea generation of IT students, ii) test empirically the effectiveness of the tool in enhancing students' creative performance in the context of an information system requirements specification task.

RESEARCH METHODOLOGY

Tool Description

The learning tool developed in this study is based on a Solo Brainstorming (SBS) method [1,2]. SBS is an individual brainstorming technique in which the participant interacts with a set of documents and identifies issues from these. The materials we used were mainly taken from a case study which was developed for teaching Information Systems at the University of Canberra [6]. In this case study, subjects worked with a portfolio of materials containing mainly interview reports concerning a fictional government agency, the Cultural Heritage Authority (CHA). There were also some abstracts included in this material which were retrieved from bibliographic databases.

A SBS session involves 'reading' and 'editing' in an environment which is supported by a formal setting [10]. This environment requires users to follow a protocol when interacting with incoming information. The protocol is designed a) to encourage users to produce divergent ideas by using their lateral thinking abilities, b) to guide users to be able to capture the main issues from documents and produce reasonable solutions for a given problem by using their analytical thinking abilities. The protocol explicitly distinguishes the merits of these two

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different thinking styles. Accordingly, after reading a document, the user is required to type a summary of the document, nominate issues from the document to be followed up and make lateral comments. The ultimate aim in the SBS session is to determine a set of issues sufficiently and to decide whether any of them should be followed up in detail. This approach allows the user to experience different stimuli. The requirements of the protocol bring richness to the user's response. Freewheeling is supported in the methodology by encouraging the user to ask questions about the problem or ideas within the document and to make speculations. Creative thinking is encouraged by allowing them to assert their own ideas.

In developing the tool, particular attention was also paid to designing the interface. It was important to prevent substantial cognitive resources from being diverted from the task in response to demands from the user-interface. The aim was to produce an interface that would have minimal impact on cognitive load, one which could be learned easily by a novice user and yet was comprehensive enough to satisfy the experienced user [5]. The application of this technique in various areas has been studied and several experiments carried out with users from various backgrounds [1, 3, 4]. The findings suggest that the SBS-based tool may be useful in stimulating the creative thinking of students in systems development tasks, particularly in the requirements specification phase.

Experimental Task

The scenario selected was related to development and implementation of an information system for a fictional government agency Cultural Heritage Authority (CHA). In the scenario envisaged in the case study, the role of CHA was to coordinate the marketing of cultural heritage in Australia. Subjects were asked to adopt the role of someone who has to write a requirements specification for a marketing information system of the CHA.

Subjects were required to generate ideas with respect to the anticipated requirements for the authority's new software-based marketing system. Specifically, subjects were asked to produce two sets of documents: one before and one after interacting with the tool provided to aid their task. Before interaction, subjects were asked to identify and record a range of potential issues they believed were important for marketing of cultural heritage in Australia based solely on their past knowledge and experience. They were then asked to interact with the tool and edit and read all available materials. After reading and editing each reading material, the subjects were required to produce a second written document, identifying additional issues and adding commentary notes.

Subjects and Procedure

A total of 16 subjects participated in the study on a voluntary basis. The participants were drawn from the pool of graduate students enrolled in a System Analysis and Design course at a large Australian university. Each received a monetary incentive of $45 for their participation. The experimental session was conducted in a microcomputer laboratory. On arrival, subjects were seated at individual workstations and worked alone. They received instructions regarding the case study and task requirements. They also had an opportunity for practice prior to commencing the experiment and to ask questions during the experiment. The session lasted 3 hours.

Experimental Design and Variables

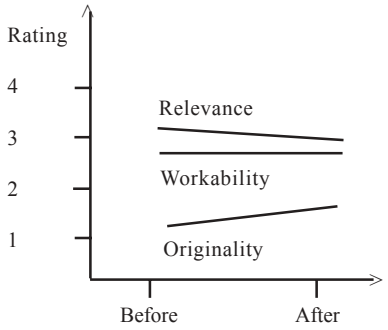
The current study used a factorial experimental design with one within-subject factor, namely *test period*. The factor was manipulated at two levels, *before* and *after* subjects' interaction with a given tool. The within-subject design was used to enable measurement of the potential change in subjects' creative performance over time.

A subject's creative performance was evaluated in terms of *relevance*, *originality* and *workability* of ideas generated before and after interaction with the tool, as assessed by an expert judge. The judge was a software developer with over 30 years of experience. The judge examined students' ideas and evaluated them for relevance, originality and workability by rating each on a 5-point Likert scale, with 1 as lowest and 5 as highest possible score.

RESULTS

In order to understand the effects of the proposed learning tool on subjects' creative performance, we statistically analysed the changes in the nature of ideas generated 'after' the interaction with the tool compared to those 'before'. The paired T-test was selected as the most suitable method for the analysis [8]. Results of the analysis are shown graphically in Figure 1.

Figure 1: Mean rating scores for participants' creative performance before and after their interaction with technology



Overall, the results of the analysis indicate that the tool had a significant positive impact on the originality of ideas generated, but had no significant impact on their relevance or workability. As shown in Figure 1, there was a significant increase in the originality of ideas generated by the participants after their interaction with the tool. More specifically, the overall mean score for originality increased significantly from 1.4 before to 1.8 after the interaction ($p < 0.01$). These scores indicated a qualitative change from mostly "very common" (low score) to "slightly novel" (high score) thoughts.

In contrast, the analysis indicated no significant impact of the tool on either relevance or workability of the ideas generated. Figure 1 shows that the mean rating score for relevance decreased slightly after interaction with the tool. However, the change was not statistically significant (3.1 vs. 3.0, ns). These scores indicated that similarly "relevant" requirements were addressed by the participants irrespective of the change in their originality.

Similarly, there was no significant change in the workability of the ideas generated due to tool use. The mean rating score after interaction was not significantly different from that before the interaction with the tool (2.5 vs. 2.5, ns). These scores also suggest that "workable" ideas were generated irrespective of their increased level of originality.

DISCUSSION

Main Findings

The main findings of the present study indicate that a solo-brainstorming based learning tool had a positive effect on students' creative performances in a systems requirements specification task. This outcome was evident in the originality aspect of task performance, but not relevance and workability. Users were found to generate significantly more original ideas as the result of their interaction with the tool, while maintaining similar levels of relevance and workability.

The results of the current study provide support for the view that creative performance can be enhanced by appropriate stimulation and instruction as suggested by some theorists [7, 9]. More specifically, the

study revealed that a significant improvement was achieved in the originality of ideas generated by the participating students due to their interaction with the tool studied here. Participants were found to shift their thoughts from very common and well-known concepts to slightly novel ones after participating in the interacting session. The results also agree with our earlier findings of improved quality of creative performance from another similar empirical study conducted in the decision-making context [4]. Essentially, the results support the idea that thinking-assisting applications can be developed, learnt, practiced and used to generate ideas. Thus, they can enable an individual to think creatively, provided that the principles are clearly understood.

Furthermore, the results of the current study indicate that increased originality did not have an adverse effect on the appropriateness of ideas (e.g., workability, relevance) generated by the participants. The study found that participants tended to continue generating similarly relevant and workable ideas irrespective of the change in their originality. This is an important finding as it suggests that the tool encouraged innovative rather than simply original thought. According to Shalley and Perry-Smith (2001), translating creative ideas into innovative products requires these ideas to be appropriate. The current study demonstrated the required appropriateness both in terms of adequate relevancy and workability of generated ideas. It is possible that the design feature of the proposed tool that provided idea storage and retrieval capabilities helped participants in final assessment.

The results of our study also indicate that the brainstorming technique underlying our tool is a promising method for stimulating creative thinking and idea generation in a software development task. It has been suggested in the literature [14] that the idea generation method is one of the most important sources of encouraging creativity. Essentially, the brainstorming session helped students uncover ideas without being constrained, stimulate their own thinking by external influences, and capture their thoughts.

Finally, the results of the study support the proposition that an electronic tool following a specific creativity enhancing technique can assist the creative process [17]. One of the main advantages of such a tool is the speed at which ideas can be produced. Furthermore, the ideas can be stored and revisited at a later time. The tool can also provide a variety of stimuli that can enhance creativity. The electronic tool tested in this study provided all of the above, plus a formal protocol that brought a much needed structure to the idea generation process.

Although the overall results of this study are encouraging, there is room for further improvement to originality. The level or originality of ideas achieved due to interaction with the proposed tool was less than desired. One possible reason for the lack of "highly original" thought may be the participants' feeling of pressure from consideration of implementation issues. Alternatively, it can be attributed to the participants' traditional IT education that placed more emphasis on developing their analytical and systems thinking skills rather than creative and innovative thinking skills. Furthermore, the subjects in the study had only one interactive session with the tool, and this might have been insufficient to produce a more substantial shift in their thinking patterns.

Implications for IT Education

Our findings may have some important implications for IT education. They suggest that creativity can be improved to an extent leading to higher quality software designs. Thus IT schools need to acknowledge this and include creativity within their courses to prepare students. It is encouraging that some governments and educational institutions are starting to emphasise the significance of promoting creative thinking of the young through education [18] and are beginning to implement changes in courses taught in business schools [13]. The results of this study suggest that the type of tool tested here may be a useful teaching tool in a variety of courses involving creative thinking and problem solving. Furthermore, the tool is likely to be most valuable in situations where the problem is unstructured, goals indistinct, and the outcome of an action cannot always be clearly identified. The tool is a rather generic one, since it uses a technique that can be applied to a variety of scenarios and can help people process relevant documents whilst identifying issues. These documents act like a 'trigger' to stimulate domain specific ideas from users.

Current Limitations and Future Research

While the current study provides a number of interesting findings, some caution is necessary regarding their generalisability due to a number of limiting factors. The application of laboratory conditions is a major limitation of this study. The conclusions drawn based on the assessments of expert judges may be biased. We also speculate that the performance of users in an interaction session can be affected by their state of mind or previous experience. The emphasis of the present study was on individual students. It would be interesting to examine the effect of the tool on the creative performance of groups. Future research may address some of these limitations.

CONCLUSION

This study proposed and empirically tested a specific learning tool aimed at stimulating creative problem solving of IT students. The tool was designed on the basis of a brainstorming technique. The essence of the tool was to provide users with external stimuli and expose them to a large number of ideas over a short period of time. The tool was tested in the context of an information system requirements specification task. The results of the test indicated that the tool was useful in enhancing creative performance of the users. After interacting with the tool, participants were able to generate more original ideas whilst still maintaining a level of relevance and workability necessary for an innovative software designs. Our findings imply that creativity can and should be taught to IT students, and that the learning tool described in this study can potentially be a valuable facilitator of the process.

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