EXPLORING THE USE OF 3D SIMULATION-BASED LEARNING TO ENHANCE THE MOTIVTION OF ENGINEERING STUDENTS

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ABSTRACT

Recent advances in technology have introduced new tools to enhance learning, especially in the context of tertiary education. At the School of Engineering in Temasek Polytechnic, Singapore, simulation-based learning (SBL) has been used to improve the engagement and motivation of engineering students in Machining Technology, a sixty hour module for second year Mechatronics students. This study investigates the effect of SBL on learners' motivation in practice-based topics, such as turning, milling and sheet metal work, which have heavy reliance on technical protocols and manipulative skills. It is hypothesized that SBL, which provides learners with first-hand, interactive learning experiences, will enhance students' motivation in content-heavy subjects, such as those offered in Engineering. In our investigations, the students in the Control group received conventional instructions and workshop practice in Machining Technology, while the Experimental group had conventional instructions, workshop practice and the benefit of SBL sessions. Both groups were given an equal amount of time on the subject. We followed a framework based on the self-determination theory (SDT) in our assessment of students' motivation. A survey was thus conducted with both the Control and Experimental groups to explore the students' perceptions in domains such as their basic psychological needs satisfaction, motivational inclination, self-efficacy, self-regulation and outcomes of learning and involvement. This presentation will highlight interim findings from the survey procedure.

KEY WORDS

Simulation-based learning, engineering, motivation, self-determination theory

INTRODUCTION

Recent advances in technology have introduced new tools to enhance learning, especially at the level of tertiary education. Amongst these, computer simulations have been used in a wide range of contexts, such as in supporting differentiated learning, collaborative learning and skill needs learning (de Freitas, 2006). The use of computer simulation to enhance learning has been particularly well studied in engineering education, with abundant literature reporting its effectiveness in improving students' conceptual understanding (Fraser, Pillay, Tjatindi, & Case, 2007) and learning process (Ndahi, Charturvedi, Akan, & Pickering, 2007).

However, whereas most of these studies focused on the enhancement of students' learning, there have been relatively fewer reports of systematic studies of the effect computer simulations on students' motivation to learn. This article will thus highlight findings from a pilot study on the use of Simulation-Based Learning (SBL) to improve the motivation of engineering students enrolled in a polytechnic course in Singapore. In this country, students have the choice between a variety of options when considering post-secondary education. On average, about 40% of the secondary school leavers opt to further their studies in the five polytechnics in Singapore (Chan, 2008). The polytechnics have a strong focus on practice-oriented learning, skills training and on the preparation of their students for the future workforce.

We adopted a framework based on the self-determination theory (SDT) in our assessment of students' motivation. According to the SDT, learner motivation is enhanced and becomes more self-determined when the three basic psychological needs for autonomy support, competence and relatedness are satisfied (Ryan & Deci, 2000). Thus, students perceive their needs for autonomy support to be satisfied when they are granted an acceptable degree of volition and independence in their learning. Likewise, perceptions of self-competence in assigned tasks when students have adequate grasp of the taught subject or skill, and learning is supported by meaningful feedback from course instructors. Finally, the need for relatedness is satisfied when students feel that they are accepted and valued by their peers and instructors within the learning environment. This study explores the impact of SBL on engineering students' perceived psychological needs satisfaction and hence, on their motivation.

METHOD

Participants

Since this was a pilot study, only a total of 58 students from two classes of the Mechatronics program were involved. They consisted of 53 males and 6 females, with a mean age of 19 years. One of the classes was designated the Control group (28 males and 2 females) and the other, the Experimental group (24 males and 4 females). A t-test carried out to assess the equivalence of the groups in terms of academic ability, showed no significant differences between the two groups.

Intervention procedure

At the School of Engineering in Temasek Polytechnic, Singapore, simulation-based learning (SBL) has been used to improve the motivation of engineering students in Machining Technology, a sixty hour module for second year students of the Mechatronics (mechanical engineering) program. In this module, students are introduced to the features and functions of machines commonly used in mechanical engineering. Course instructors often observe that students have difficulty recalling the functions of these machines and the specific use of their various components. It was hypothesized that computer simulations which provide learners with first-hand, interactive learning experiences, will improve students' motivation and enhance their mastery of the required skills. Since there were no simulations currently available in the market that cater specifically for the requirements of this course, three simulations on the functioning of

the milling, turning and drilling machines were therefore developed by some members of the project group. The simulations were distributed into 3 main units, "Explore", "Demonstration" and "Test". The "Explore" unit allows students to explore the digital replica of each machine, the various component parts and how they could use them to perform various tasks. The "Demonstration" unit guides students on specific cutting operations. The "Test" unit allows students to perform self assessment on the cutting operations.

During the intervention period lasting six weeks, the students in the Control group had the conventional, weekly lessons (2 hrs), followed by workshop practice (2 hrs) in Machining Technology, while the Experimental group had the benefit of SBL sessions (30 min) in addition to the traditional instructions (2 hrs) and workshop practice (1hr 30 min).

Assessing students' motivation

Following the intervention procedure, a survey was conducted with both the Control and Experimental groups to explore the students' perceived basic psychological needs satisfaction, motivational inclination and self-efficacy. We used a 5-point Likert scale, ranging from 1 (strongly agree) to 5 (strongly disagree), for the scoring of all the questions. The survey items were adapted from a number of established instruments that were used and validated by other researchers. Thus, 8 items were adapted from the general self-efficacy scale (GSE) by Jerusalem and Schwarzer (1995), 10 were adapted from the Academic Self-Regulation Questionnaire (SRQ-A, Ryan and Connell, 1989) for the measurement of intrinsic motivation. Extrinsic motivation was assessed using 4 items from the SRQ-A and from a modified version of Harter's (1981) scale for the measure of individual differences in motivation (Lepper, Corpus and Iyengar, 2005). To assess students' perceived satisfaction of the psychological needs, we adapted 5 items on autonomy support from the Learning Climate Questionnaire (Williams and Deci, 1996) and 10 items (5 on competence and 5 on relatedness) from the Intrinsic Motivation Inventory (IMI, McAuley, Duncan and Tammen, 1989). Cronbach's alpha was computed to assess the internal consistencies of the subscales.

Results

Table 1 shows the mean and standard deviation for the perceived needs satisfaction and motivation subscales. Low mean scores indicate positive needs satisfaction and enhanced motivation. In this study, mean scores ($\bar{x}$) below 1.6 are arbitrarily designated as low, while for moderate mean scores, $1.6 \leq \bar{x} \leq 3.3$. High mean scores are those above 3.3.

Table 1: Mean, SD and alpha coefficient for Control and Experimental groups

Subscale	*Control*		*Experimental*		
	Mean($\bar{x}$)	SD	*Mean($\bar{x}$)*	SD	*Alpha*
Self efficacy	2.36	0.91	2.33	0.77	0.84
Autonomy support	2.87	1.20	2.41	0.66	0.73
Competence	2.33	0.82	2.21	0.57	0.77
Relatedness	2.75	1.14	2.34	0.85	0.28
Intrinsic motivation	2.71	1.02	2.59	0.82	0.81
Extrinsic motivation	2.44	1.26	2.52	1.13	0.08

Table 1 shows that students in both the Control and Experimental groups perceived moderate satisfaction for all three psychological needs. Comparing the latter, satisfaction was highest for competence and lowest for autonomy support. The Experimental group obtained lower means than the Control group, for all subscales except 'extrinsic motivation' for which the outcome was reversed. Values of Cronbach's alpha were high (>0.70) for all subscales except for 'relatedness' and 'extrinsic motivation'. A preliminary F-test for the equality of variances indicated that the variances of the Experimental and Control groups were significantly different ($p<0.001$). A two-sample t-test, assuming unequal variances, however showed that the overall scores for the Experimental group were not significantly different from those of the Control group. However, further analyses of individual subscales showed significant differences between the two groups for autonomy support and relatedness, but not for the rest of the subscales.

Table 2 presents the correlations between the variables used. The three psychological needs were weakly correlated. Moderate to high correlations were obtained between intrinsic motivation and other subscales, whereas extrinsic motivation showed low correlations with other variables except self-efficacy. Correlations between self-efficacy and the psychological needs were low, with the exception of autonomy support for which a moderate correlation was obtained.

Table 2: Correlation matrix of the variables

Experimental group					
	Self efficacy	*Autonomy*	*Competence*	*Relatedness*	*Intrinsic*
Self efficacy	1.00				
Autonomy	0.50	1.00			
Competence	0.30	0.06	1.00		
Relatedness	0.10	0.15	-0.13	1.00	
Intrinsic	0.70	0.43	0.43	0.33	1.00
Extrinsic	0.49	0.03	-0.01	0.01	0.02

Discussion and conclusion

Although these findings may not be generalizable due to the small participant sample, they nevertheless reflect the possibility of students in the Experimental group having experienced greater satisfaction of their basic psychological needs, especially that of autonomy (as compared to the Control group), due to their exposure to SBL. Enhanced perceived needs satisfaction might, in turn, have led to higher self-efficacy and intrinsic motivation, but reduced extrinsic motivation. This study shows students' perceived satisfaction to be highest for competence, followed by relatedness and thirdly, autonomy support. These findings differ from those in an earlier study on polytechnic engineering students, whereby the researchers observed highest satisfaction for relatedness, and at decreasing levels, competence and autonomy support (Liu & Chye, 2008). One could suggest that the teaching strategies used in the current study contributed at least in part, to a higher perceived competence amongst the students (both Control and Experimental groups), and that students who experienced SBL perceived higher satisfaction in relatedness and autonomy support that their peers in the Control group.

However, the results should be interpreted with caution, since the internal consistencies of two of the subscales were not satisfactory. The low alpha value for 'relatedness' may be attributed to discrepancies arising within the subscale as a result of adapting the original items to the current context of a mechanical engineering course. Finally, the low internal consistency obtained for the extrinsic motivation subscale may be due to the fact that unlike intrinsic motivation, which is essentially a one-dimensional construct, extrinsic motivation tends to be multifaceted (Lepper et al, 2005) and exists as a continuum of increasingly self-determined behaviours (Ryan and Deci, 2000). Thus, ranging from external regulation (most controlled) to identified regulation (most autonomous). Thus the items included in the subscale could have described more than one type of extrinsic motivation.

The outcomes of this pilot study have shown that SBL has a positive effect on students' motivation. In addition, it has provided clear indications for future developments in the current study. Improvements to the survey instrument should include subscales on the various types of extrinsic motivation and a systematic revision of the items on 'relatedness'.

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