Piloting experiential learning through 360ºVideo and 3D printing to improve system modelling

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Piloting experiential learning through 360^0 video and 3d printing to improve system modelling

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ABSTRACT

This research investigates the impact of experiential learning methods in teaching system modelling in higher education ICT classroom. We hypothesize that the integration of visualization and gamification by incorporating 3d printed objects and a virtual video 3600 case scenario can improve learning motivation, engagement and enhance learning outcomes.

The data was gathered through a usability test using a Likert scale from students (n=24) of two conditions (control group n=12 and experimental group n=12) using a design-based research methodology. Significant results were found for 11 of the 14 usability questions asked of the participants during the study. Preliminary results show that the experiential learning activities promote engagement and motivation and have a positive effect on learning. Using 3d printed objects provides an added layer of facilitated interaction for individuals and between learners on the usability measures of manipulability, memorability, navigability and communication. However, measures of creativity, visibility and efficiency were not significant due to the delivery and novelty of the approach. Based on the positive results of the usability test further work is required to refine the intervention. This includes unpacking the effects of visualization and gamification on motivation, engagement and learning in system modelling.

CCS Concepts

• Computer Systems • Information Systems • Computing Methodologies

Keywords

experiential learning, system modelling, ICT education, design-based research, 3d printing, 360 video

1. INTRODUCTION

The use of unified modelling language (UML) allows designers to describe various components of the system. However, it does not describe a process for capturing requirements [10]. When using UML, learners are challenged to conceptualize a problem domain or narrative for better modelling decisions [27]. Some of the difficulties of understanding the system itself can lead to disconnection and therefore learning disengagement [11].

Traditional learning approaches in system modelling have been challenged with regards to students' understanding including learning performance and mastering of modelling techniques. The use of multimodal learning environments can be used in ICT system analysis & design to enhance critical thinking, improve problem-solving activities, support system thinking and promote learning [2].

Important progress has been seen in the use of multimodal visual representations such as 3d printed objects and 360 video as they apply to education and training [1]. These characteristics in conjunction with other methods such as incorporating game-based learning in the classroom can offer enhanced feedback to facilitate understanding compared to the traditional didactic or written approaches [5].

The use of interactive visualization through multi-dimensional graphics and simulation could provide an opportunity to present key learning content for students using multiple representations [6; 18]. Multiple representations support a variety of learning activities and can provide unique benefits when students are learning new concepts or complex ideas [1].

3D printing has been utilised to support learning in a range of educational and training contexts. The human sense of touch is a dynamic, informative, and convenient perceptual system to connect and construct meaningful understanding [17]. The efforts to use image-based 3D printing tools to create models and molds have been used for medical learning environments, additive manufacturing design and manufacturing processes [3].

The use of 3D printing haptic tools has the potential to produce informative representations and can be used for science, technology, engineering, and math (STEM) topics [19]. Interactive and hands-on learning environments are considered as promising strategies for providing instructional content that allows the learner to engage actively in the learning process [15].

Another emerging approach, gamification, is described as the incorporation of game technology and game design methods with the purpose of solving problems and engaging users [8]. Gamification is the incorporation of game elements and game mechanics into a non-game context [16]. The role of gamification is to evoke psychological experiences that match a game environment by applying the mechanics of gamification in educational settings [12; 14].

According to [10] gamification's main goal is to raise the motivation of users by incorporating game-like techniques such as scoreboards, situational scenarios and adapted feedback [25]. In addition, [22] refers to the ongoing feedback provided to participants in games such as Tetris. There is visual (pieces), quantitative (score), and qualitative (levels) feedback provided during the game; yet traditionally it is challenge for educators to recognize the importance of feedback, and when and how to provide it on student work [22].

Taking 3D printing into the area of instructional design programs will also benefit students [21]. According to Howard and Vance (2007) [16] a combination of haptics and physically based modelling significantly improved learning motivation and provided a more realistic virtual assembly experience. In addition, visualization and gamification facilitate methods of interacting with information [5,7] and have positive effects and benefits in the classroom [18]. Many students face difficulties in conceptualizing, which leads to difficulties scaffolding and understanding theoretical models particularly around the complexities of system design thinking [24]. As a result, educators are challenged to find new avenues of representing abstract system thinking into more concrete design thinking that opens more opportunities for clearer conceptualization of systems, interaction and design experiences [2, 25].

Understanding the problems of system abstractions can improve students' understanding of modelling. Visualization combined with game elements shows potential to assist students with system modelling. We hypothesize that the integration of visualization and gamification by incorporating 3D printed objects can improve learning motivation, engagement and enhance learning outcomes. The developing modelling skills in system analysis and design accounts for conceptualizing and translating ideas into models.

This study contributes to the current body of literature on learning the challenges, skills needed and immersion using experiential multimodal methods and how they can scaffold learning in new ways, so learners are motivated in the learning experience. An essential question that arises from this study is how visualization using 3D printed components and 360 video can be used as a method to assist students with their comprehension of systems and reduce the problem complexity by using visual representations of the system and its abstractions. In the usability testing, we investigated the relationship among these variables, and the extent to which they enhance learning. The proposed method is designed to enhance students' knowledge and skills in system modelling as well as to provide informative representations for cognition.

2. RESEARCH METHODOLOGY

The aim of this research is to investigate the learning performance and engagement of students using visualization and 3D printed objects in a game-like context when learning ICT system modelling. This section presents a research methodology that describes the actions taken to define problems encountered when modelling ICT systems through UML and provides a theoretical foundation to answer the research questions.

This work will adopt the 4C method (see Figure1) for testing as proposed in [24]. This framework proposes a sequence of activities developed to facilitate understanding of the requirements, solutions and incremental modelling development. This method will guide students with solution support to build a model by using four steps (Conceptualization, Connection, Construction and Consolidation). This 4C method loops through specific steps and a series of iterative implementation of experiments to test learners' modelling improvements. In this research, the 4C framework informs an underlying design-based research (DBR) methodology as proposed by [25].

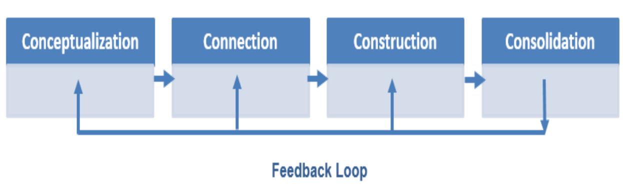

Fig. 1. The '4C' Framework

Due to the flexibility and adaptability of DBR, it has been used across a range of educational environments including conducting research in the classroom [26] and designing instructional learning environments in information systems [15]. DBR offers a cyclical loop that simultaneously addresses and reflects on the analysis of the problems and its practicality [2] (see Figure 2).

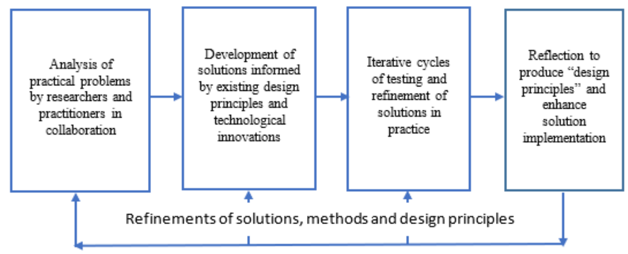

Figure 2. Design Based Research Cycle (2008, p.34) [2]

There are currently proposed three loops for the experimental implementations of the larger study and each loop involves the use of the DBR in an ongoing manner. However, for this study only the implementation for Loop 1 will be examined as a base for tool evaluation and effectiveness of the modelling solution.

The implementation of Loop 1 included the use of visualization where students interacted, discovered and immersed in the visual case scenario. This incorporated a set of 3D models that represented users, activities and connections. This activity assisted students in a gamified learning context and can be used to reinforce engagement based on students' actions. Participants in the study are recruited from an Australian university enrolled in a systems analysis unit from and ICT program. Ethics clearance has been granted for this study before running the experiment.

A sampling of (n = 24) ICT first-year student participants were randomly assigned to one of the two experimental conditions across two tutorials. Twelve participants were assigned to the control group condition (CG), while twelve were assigned to the experimental group condition (EG). All participants (students) received a short lecture power point slide highlighting the 4C framework that provided an overview of the process of constructing their model (see Figure 3). Students had a base line competency in using UML before starting the experiment.

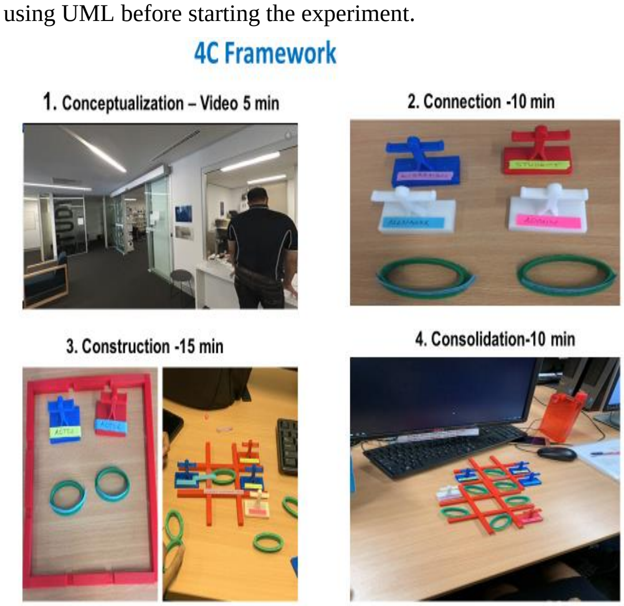

Figure 3. 4C framework steps

Students were then divided into two groups and participated in the intervention which was followed by a usability test outlined in Table 1 – and validated in [4].

Table 1. Usability Assessment Survey

[Likert Scale 1 no relevant – 5 very relevant - use 0 for N/A]						
1. Accessibility: *Visualization is readily accessible*	0	1	2	3	4	5
2. Learnability: *Visualization is easy to learn*	0	1	2	3	4	5
3. Efficiency: *Visualization is efficient to use*	0	1	2	3	4	5
4. Satisfaction*: Visualization provides satisfaction (confidence) of the design*	0	1	2	3	4	5
5. Memorability: *Visualization is "sticky" and memorable to support the design*	0	1	2	3	4	5
6. Error Free: *Visualization is free from visual and design errors*	0	1	2	3	4	5
7. Manipulability: *Visualization can be manipulated - e.g. rotation, time, amplify*	0	1	2	3	4	5
8. Navigability: *Visualization allows the user to change their viewpoint*	0	1	2	3	4	5
9. Visibility: *Visualization provides clear detail to interpret the design*	0	1	2	3	4	5
10. Real world: *Visualization provides a match to the real world*	0	1	2	3	4	5
11. Communication: *Visualization aids stakeholder design communication*	0	1	2	3	4	5
12. Creativity: *Visualization allows the user to be creative with the design*	0	1	2	3	4	5
13. Engaging: *Visualization is meaningful*	0	1	2	3	4	5
14: Motivating: *Visualization provides acceptance of the design*	0	1	2	3	4	5
Additional Comments						

The traditional method control group received a narrative of the case study describing the library booking system and where students had to read the narrative before they identify all the actors using the library system. They then defined the requirements and meaningful connections by drawing use cases onto a piece of paper (see Figure 4).

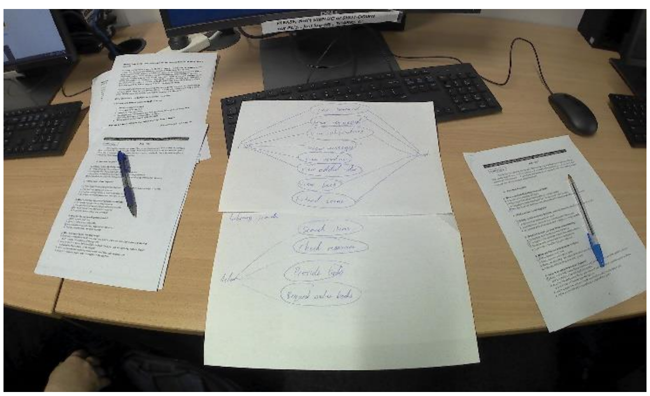

Figure 4. Written narrative and use case representation

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The experimental group watched a 360^0-video presenting a virtual case study presenting a library booking system where they were able to explore, extract and classify information (see Figure 5) to represent a use case model using 3d components (see Figure 6).

Figure 5. Virtual case study

Figure 6. Use case model representation

Following this, in groups of three, students identified the number of actors and entities involved using 3D physical representation of UML symbols to help them to connect their findings. The experiment focused on syntax learning and system modeling analysis, comprehension of system modelling.

For this purpose, the use of 3D tools posed as syntax symbol representations (see Figure 2). Once students selected and classified the relevant actors and activities they presented and progressively described their findings in class. The inclusion of an interactive video to present the case study supported by 3d printed tools are both visual aids to assist students through the different phases of the 4C framework. The video allows students to conceptualize in the first phase by reducing cognitive processing through immersion compared to traditional reading. Whereas the 3d printed tools allow the recognition of the syntax to be used to classify actors and make connections (second phase), construct activities (third phase) and consolidate the previous steps (fourth phase).

3. RESULTS

The administered usability survey is presented in Table 1, in which each measure was ranked on a Likert Scale of 0 to 5, where 1 is not relevant and 5 is very relevant. Results of the usability test were analyzed using SPSS. Table 2 presents the paired statistics of the usability test. Table 3 presents the results of the usability test. A paired sample t-test was conducted to determine if a statistically significant difference existed between usability questions from a control group (CG) and experimental group (EG).

There was a significant difference in the scores between CG and EG conditions for the measured usability test including *motivating*, CG (M=3.38, SD=1.313), EG (M=4.46, SD=0.658) t(23)=3.680, p =0.001; *engagement*, CG (M=3.38, SD=1.398), EG (M=4.46, SD=0.779) t(23)=2.229, p =0.036 and *learnability* CG (M=3.54, SD=1.382), EG (M=4.42, SD=0.83) t(23)=2.235, p =0.035). Significant results and non-significant results for the usability measures can be found in table 3. The preliminary results of the usability test as hypothesized show that the intervention has a positive effect on motivation, engagement and learning.

Table 2: Paired Samples Statistics CG vs EG of the usability test

Assessment Measure	Mean	N	Std. Deviation	Std. Error Mean
Accessibility EG	4.25	24	0.737	0.15
Accessibility CG	3.46	24	1.179	0.241
Learnability EG	4.42	24	0.83	0.169
Learnability CG	3.54	24	1.382	0.282
Efficiency EG	4.29	24	0.69	0.141
Efficiency CG	3.63	24	1.245	0.254
Satisfaction EG	4.25	24	0.676	0.138
Satisfaction CG	3.63	24	1.209	0.247
Memorability EG	4	24	0.722	0.147
Memorability CG	3.29	24	1.16	0.237
Error Free EG	4	24	0.78	0.159
Error Free CG	2.63	24	1.313	0.268
Manipulability EG	4	24	0.978	0.2
Manipulability CG	3.21	24	1.179	0.241
Navigability EG	4.21	24	0.779	0.159
Navigability CG	3.54	24	1.215	0.248
Visibility EG	4.17	24	0.761	0.155
Visibility CG	3.58	24	1.06	0.216
Real world EG	4.25	24	0.676	0.138
Real world CG	3.46	24	1.318	0.269
Communication EG	4.21	24	0.658	0.134
Communication CG	3.58	24	1.139	0.232
Creativity EG	4.29	24	0.69	0.141
Creativity CG	3.75	24	1.225	0.25
Engagement EG	4.46	24	0.779	0.159
Engagement CG	3.71	24	1.398	0.285
Motivating EG	4.46	24	0.658	0.134
Motivating CG	3.38	24	1.313	0.268

Table 3. Paired sample t-test: Control vs Experimental Group, and p values for significant (s) and not significant (ns) differences.

Assessment Measure	Mean	Std. Deviation	Std. Error Mean	t	p-value	significance
Accessibility	0.792	1.587	0.324	2.443	0.023	s
Learnability	0.875	1.918	0.392	2.235	0.035	s
Efficiency	0.667	1.606	0.328	2.033	0.054	ns
Satisfaction	0.625	1.439	0.294	2.128	0.044	s
Memorability	0.708	1.398	0.285	2.482	0.021	s
Error Free	1.375	1.583	0.323	4.256	0	s
Manipulability	0.792	1.587	0.324	2.443	0.023	s
Navigability	0.667	1.551	0.317	2.106	0.046	s
Visibility	0.583	1.442	0.294	1.982	0.06	ns
Real world	0.792	1.769	0.361	2.193	0.039	s
Communication	0.625	1.439	0.294	2.128	0.044	s
Creativity	0.542	1.56	0.318	1.701	0.102	ns
Engagement	0.75	1.648	0.336	2.229	0.036	s
Motivating	1.083	1.442	0.294	3.680	0.001	s

4. DISCUSSIONS

We investigated the impact of presenting a case study using a 360^0 video, supported by using physical objects such as 3d printed tools embedded in a gamified way to assemble a system model. A paired t-test was run to determine whether there were statistically significant usability aspects and what are the most important pedagogical advantages of using visual enabled multimodal learning for system modelling, specifically focused on learning use case modelling.

Table 2 presents the results of descriptive statistics for the two conditions of the usability measure for the control group and experimental group. The mean of *learnability* measure in the EG is higher compared to the CG, 4.42 and 3.54 respectively. The mean of *engagement* in the EG is 4.46 compared to 3.71 in the CG. The mean of *motivation* measure is 4.46 in the EG and 3.38 in the CG. These above-mentioned results suggest that multimodal information does have an effect when learning. As presented in the results, standard deviation for the learnability, engagement and motivation measures in experimental conditions shows lower deviation results compared to the control condition.

Table 3 presents the results of the paired samples t-test of the usability measures. As hypothesized, there was a significant difference in the *p*-value for *learnability* (0.035), *engagement* (0.036) and *motivation* (0.001). These results show statistically significant on the <0.050 alpha. Usability results were also significant for the intervention on accessibility, satisfaction, memorability, error-free, manipulability, navigability, real world and communication. The nature of the 3D tools can help students with the manipulability, memorability, navigability and communication as it provides an added layer of facilitated interaction for individuals and between students. Positive results on the accessibility and real-world measures can be associated to the visual 360^0 interaction and consequently students' satisfaction, engagement and motivation provides a foundation for learnability.

In terms of *efficiency*, *visibility* and *creativity* scores, the *p*-value results indicate that for these measures there is no significant difference between working in a gamified activity or using a traditional learning activity. Lack of efficiency may be due to the piloting nature of this initial loop 1 intervention. Similarly, lack of creativity can be associated with the novelty of this type of intervention. A non-significant result for visibility can be assigned to the lack of a clearer visual introduction and background of the case study.

5. CONCLUSIONS

The use of multimodal learning environments and gamification can be used in ICT system analysis & design to enhance motivation and engagement and learning. These characteristics in conjunction with incorporating 3d printed modelling components can facilitate understanding compared to traditional approaches to teaching modelling. These enhanced interactive activities can effectively increase level of engagement and motivation and have a positive association on learning. Also, the use of 3d printed components can help students to manipulate, navigate/modify and communicate their models

6. ACKNOWLEDGMENTS

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