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Enhancing Real Life Expertise in Construction using Virtual Environment Simulation

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Abstract

This article progresses the research cycles outlined in the Level3 article of March 2015. It starts with sufficient information for the reader to understand the first stages, and subsequently explains the thinking behind the third cycle and the rationale for testing through an expert focus group. This includes the analytical questions to be posed to the focus group regarding the possible theoretical underpinnings of the virtual learning scenario device and consensus towards further development and testing.

Key words: learning theory set; cognitive absorption; focus group testing; feedback.

1. Background and overview

This article is a progression of research cycle three as described in the March 2015 Issue of Level3:

'Developing a user scenario design for testing a novel web-based education system for built environment education'

That earlier article describes how, as a result of the first two research cycles, we discovered it is now possible for the novice graphics modeller to build detailed simulation of procedural construction engineering activities. This led us to the concept of developing a generated Web-based 3D virtual simulation of an engineering workshop in refrigeration plant maintenance. The conceptual simulation was constructed as a Web-based application using a game engine software platform. To extend the Web-based application towards the concept of becoming a knowledge and skills acquisition model as a web-based stimulation system (WBSS), or virtual replication of the real life workshop teaching experience, a further cycle of research is now required. For research cycle 3, a conceptual theoretical design framework is proposed as a fusion of two theory sets which will be tested with education and subject matter experts through focus groups sessions.

The design questions posed to the focus groups in the third research cycle outlined in this article are intended to utilise the reasoning model discussed in our state of the art review paper [1] to extend the application to a higher level and to lessen any original design defects for the subsequent research cycle 4 - the pilot testing phase.

The article is organised into three parts.
In the first part the research question to be posed to the focus group and the two theory sets are outlined.
In the second part the vision and objectives for research cycle 3 are detailed.
In the third part the focus group process is explained including the guiding analytical questions for focus group members to provide feedback in relation to the two theory sets.

Part 1: Research cycle 3: Questions posed and plan for the focus groups

Research Cycle 3 Questions
If an engineering workshop and its environment is replicated virtually as a teaching tool using high end animation/graphics and audio:

1. Can the additional application of psychological, cognitive, and perceptive learning theories improve the design and thus the pedagogic results?
2. How can these theories be integrated into the design of the web-based stimulation system (WBSS)?

To explore possible answers to these questions a plan and strategy to convene an interactive Focus Group has been decided. The plan is to develop teaching and learning scenarios related to specific subject matter based on two theory sets, as follows:

Theory set 1: engagement theory; motivation theory; flow theory; immersion theory; cognitive absorption theory; schema theory.

Theory set 2: cognitive enablers theory; technological enablers theory; social enablers theory.

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When these scenarios are developed the strategy is to test each theory from the two sets in relation to the scenario learning examples using interactive focus group methods. The intention is to collect ideas which can contribute answers to the questions posed about the design questions and to generate design solutions where problems are identified.

Part 2: Research cycle 3 - Vision and Main Objectives

The research problem stems from a real-life pedagogical problem on a refrigeration engineering course related to plant maintenance: how can web-based technologies be used to enhance learning from practical engineering workshops for students who are either off-campus or who do not learn effectively in workshop settings?

The initial concept to develop 3D learning applications which virtually replicated the content and process of the workshops had proven in research cycle 2 that technology driven simulated education often runs the risk of being overly biased towards the technology platform [2]. As a consequence of this, the original conceptual idea turned out not to be a particularly novel solution in itself. Although it could potentially solve the learning problems for many students, it may not necessarily enhance their problem-solving, higher level thinking skills. A vision for refining the 3D learning application to become a complex edu-game should ideally consist of multiple unpredictable events which will both engage the students' cognitively and affectively, while enhancing their problem-solving skills within refrigeration engineering.

Cognitive absorption of knowledge and skills can be influenced in a web-based simulation system (WBSS) by introducing perceptive and psychological immersive techniques as a fundamental element of the design framework. The WBSS tries to replicate the real-world classroom by using the most current software and hardware. Immersive technologies provide the additional human senses beyond visual - sound, touch, smell, impact. Immersive hardware technologies are expensive and not always accessible to the student population. Therefore it is proposed to introduce both perceptual and psychological immersive techniques to provide an enhanced interactive and reactive learning experience. Building on what is already known from schema theory employed by cognitive psychologists [3] and artificial intelligence (AI) researchers, it is possible to chart how information processing can shape perception and action [4].

What is known for certain is that today's students are both digitally-experienced and digitally-intuitive and seem to learn effectively when multiple senses are engaged in tasks. Digital learners frequently spend hours playing digital games, often returning to the same game over and over. They invest huge amounts of leisure time and energy in mastering complex game rules and strategies [5]. As a result of the time and energy digital learners devote to playing games it is appropriate to explore the power these games have to motivate and engage users. Research literature that linked *engagement* and *motivation* to effective learning has led to exploring the use of serious gaming as potential tools for designing an initial WBSS [6-9].

Objectives of the third research cycle

The objective of the third research cycle is to synthesise engineering/construction education and e-gaming pedagogies together to develop a conceptual pilot for students. The focus group design will draw on knowledge derived from experts and peers in computer science. The three steps in the design are as follows:

1. To explore the principal psychological learning theories and cognitive immersive behaviours.
2. To integrate these theory sets into the design mix to improve the restricted 3D stimulation.
3. To validate the conceptual design for experimental testing in the subsequent research cycle 4.

Part 3: Methodological approach using focus groups

For this third research cycle, focus group methodology will be used as a qualitative approach to gather data about the theoretical underpinnings of the web-based stimulated learning system. The focus group participants will be asked to express their opinions and offer their expertise about the following:

(i) workshop equipment replicated in 3D as virtual compared to real-life context

(ii) voice communication with arrow indicators and *fully-operational* processes

(iii) manipulation of the 3D equipment and ability to replay elements where necessary

(iv) provision to test knowledge and understanding of each element and stage, repeating as many times as possible

(v) Yes/No to tracking of student activity and methods to encourage self-styled learning

(vi) functions to enable student/users to demonstrate to teaching staff that they had achieved the required learning to the specified level in relation to the module learning outcomes.

Proposed content development for Focus Group Sessions

To facilitate a focused discussion and to ensure all individuals have the opportunity to participate during the session, it is intended to develop the following:

(i) a visual learning scenario
(ii) videos demonstrating how this learning scenario is taught in the classroom and online
(iii) a survey questionnaire.

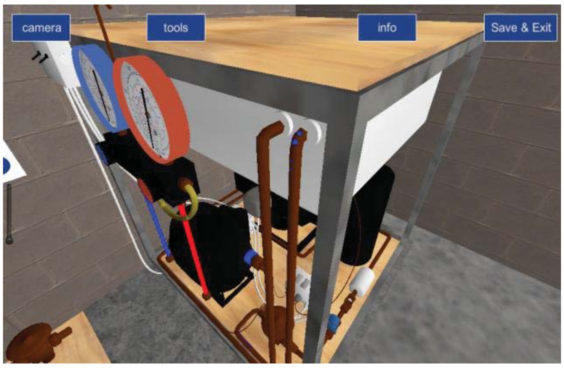
The development of informative content for the subsequent stage will be as a direct result of the outcome from the focus group sessions.

The focus group experts will be invited to critique and provide developmental feedback on the simulation steps already developed, based on the two learning theory sets outlined earlier.

Step 1: Provide a visual learning scenario: '*Demonstrate your ability to fit a service gauge manifold to an operational system containing F-Gas. Ensure you comply with both health and safety and environmental obligations'.*

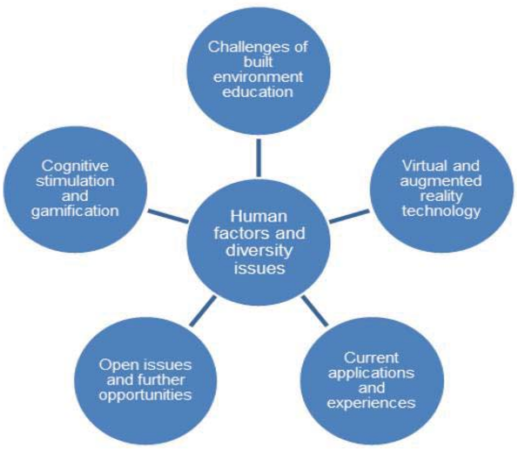
Step 2: Provide a short video demonstration showing how co-located students are tutored on how to complete this learning scenario in the classroom

Step 3: Provide a short video demonstration showing how the dislocated students could be tutored on how to complete this learning scenario using the WBSS.



Step 4: Provide guiding questions for the focus group members which will provide collated data pertaining to theory sets 1 and 2, and subsequently to enhance the scenario simulation to more complex levels.

Guiding questions for focus group sessions



This reasoning model developed in research cycle 1 summarises the objectives and data sources for our focus group questions. The success of VR technology is dependent on: (i) the human user at the core, (ii) the application challenges in construction engineering education, (iii) the sophistication of VR and AR technologies. The level of acceptance of a WBSS implementation has a correlation with how the technology supports the illusion of human senses when interacting in the virtual space [1].

A. Questions about the student

When students are in a classroom, what cognitive enablers does a tutor use to engage and motivate his/her audience?

The focus group task is to list the cognitive enablers which come into play for both teacher and student during face-to-face teaching when allowing for varied learning styles of modern students. They will discuss how a tutor's ability to read body language and facial expressions can help determine the level of comprehension of students and enable him/her to adapt his/her teaching technique (delivery) accordingly. They will compare this technique to the various activity-based teaching techniques and determine if these tested delivery methods are an effective substitute for traditional lecture/teaching techniques and general teacher intuition.

B. Questions about the technology

What technological enablers do digital game developers use to generate 'flow', cognitive absorption and perceived immersion?

C. Questions about the interaction of the user with the technology

Log onto the user website to complete the visual learning scenario. Then answer the following:

Strongly Disagree; 2= Disagree; 3= Neutral; 4 = Agree; 5 = Strongly Agree.
1 The WBSS is easy to access and navigate. **1 2 3 4 5 N/A** ☐ ☐ ☐ ☐ ☐ ☐
2 The interface is intuitive, easy to understand and has the potential for flow. **1 2 3 4 5 N/A** ☐ ☐ ☐ ☐ ☐ ☐
3 The controls are straight-forward and provide for a natural real-world operation **1 2 3 4 5 N/A** ☐ ☐ ☐ ☐ ☐ ☐
4 Navigation around the WBSS is fluid and has the potential to create perceptive immersion. **1 2 3 4 5 N/A** ☐ ☐ ☐ ☐ ☐ ☐
5 The 3d models are a good representation of the real -world components and therefore have the potential to create cognitive absorption **1 2 3 4 5 N/A** ☐ ☐ ☐ ☐ ☐ ☐
6 The procedural test scenario gives a real world perspective **1 2 3 4 5 N/A** ☐ ☐ ☐ ☐ ☐ ☐
9 The WBSS is affective as a teaching tool to prepare students to engage with competence and confidence with real world operating systems **1 2 3 4 5 N/A** ☐ ☐ ☐ ☐ ☐ ☐

D. About the interaction of the technology with human user

Explain the basic fundamentals all technology must have at its core to engage and motive users.

Anticipation of research cycle four

The outcomes of cycle three will necessarily be complex and possibly contradictory.

A second set of questions for the focus group may be necessary to achieve sufficient clarity to plan the subsequent cycle.

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