Productive failure in inquiry learning in a multi-user virtual environment

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This research focuses on analysing the impact of structure in inquiry learning activities in a Multi-User Virtual Environment. Productive failure is a learning strategy that has shown that using a low structure initial activity in inquiry learning can result in better learning outcomes than using an initial high structure activity. *Virtual Singapura* is a multi-user virtual environment that presents learners with the opportunity to engage with a visually rich, authentic and dynamic environment that enhances a student's engagement with inquiry learning. This research aims to inform research on productive failure and the structuring of inquiry based activities in virtual environments.

Keywords: Multi-user virtual environments, pedagogy, inquiry learning, structure, productive failure

Introduction

The aim of this research is to gain an understanding of how learners engage with inquiry learning in *Virtual Singapura* (VS) a Multi-User Virtual Environment (MUVE). The research will compare the processes that students use during the initial stage of low structure and high structure inquiry activities. Structure in this instance relates learning directives and supports such as prompts, questions, directions, peer feedback and discussions. The research will also compare the results of students' pre, mid and post test scores to ascertain if there is a significant difference between the groups. The use of unstructured initial activities is derived from Kapur's Productive Failure (PF) learning strategy (Kapur, 2006; 2008; 2009). The findings from the preliminary research into PF indicate that participants who were exposed to an unstructured initial activity achieved significantly better results in post tests compared to participants in the control group when solving inquiry problems.

Background

The development of educational MUVES presents educators and learners with a multitude of possibilities to garner an enriched learning experience. The benefits of MUVE environments include encouraging exploration and problem solving; non-linear or multiple routes of goal solving, interaction with other players, risk taking, customisation of the environment, player agency, situated meaning, and performance before competence (Gee, 2003, 2005). MUVEs can afford enhanced visualisation of complex phenomena; can allow for multiple perspectives and can bring together a large group of students for a collaborative learning experience, a situation that may be difficult to replicate in a normal classroom environment, but one which can result in a learner being more psychologically present (Bailenson et al., 2008).

Increased motivation and student engagement are two aspects of MUVE and game usage that appear frequently in the context of game research. The "real world" context and rich immersive environment are cited as being motivating factors for learners – the intense visual, aural and textual stimulation support the learning of material in context (Rieber, 1996; Shaffer & Gee, 2007). Squire (2005) adds that e-learning, in general, is dull, but that games can be engaging and fun as participants start with failure and build success through challenging flaws in their knowledge.

New and developing technologies have the potential to improve student learning as previously difficult to visualise topics such as scientific data can be presented in a manner that is accessible for learners

(Barnett, Yamagata-Lynch, Keating, Barab, & Hay, 2005). In fact, in fields such as science the use of MUVEs enable learners to visualise complex data that is often difficult to process abstract concepts (Squire, Barnett, Grant, & Higginbottom, 2004). The opportunity to move beyond the usual 2D classroom dynamic engages students, this use of MUVEs in inquiry learning can engage and motivate students in fields that are often difficult to visualise, such as the disease epidemics scenario of *Virtual Singapura*.

Much of the research in MUVEs has focused on how learners respond to the virtual environment, the purported learning benefits and the technological developments. MUVES such as *Quest Atlantis* support the use of guided inquiry activities (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005). A guided inquiry sequence commences with highly structured activities that guide a learner through the virtual space and then fades the structure out as the learner progresses through the activities (Nelson, 2007). This research proposes that a treatment that uses the opposite arrangement - beginning with low structure activities and increasing structure in the subsequent activity can also provide benefits for the learners.

Productive failure

PF provides an alternative approach guided inquiry or highly structured inquiry activities. Current research on the impact of PF treatments has shown that greater learning is achieved when students are presented with a cycle of low structure, high structure, and low structure activities (Kapur, 2008; Kapur & Kinzer, 2009). While students may struggle and ultimately fail in the initial unstructured encounter they are supported with a structured activity in the second phase of the treatment. This paper suggests that it is the placement of the low structure activity in the initial encounter that results in learning.

PF as allows students to fail or reach an impasse. Often instructors shy away from allowing students to reach an impasse; however, research by VanLehn et al. (2003) and Kolodner (2006) indicates that allowing students to reach an impasse may encourage student to think more critically about a situation and that reaching an impasse can encourage learning. Research into PF has shown that students using a PF treatment show more feedback loops and explore a wider range of possible courses of action than students engaged in a guided activity, which shows that students are exploring the situation rather than being led through an activity to a successful outcome (Kapur, 2008; Kapur & Kinzer, 2009; Pathak, Jacobson, Kim, Zhang, & Feng, 2008).

The underlying premise of this strategy is that structure or scaffolding can impose order, but limit a learner's exploration of the complex problem to the constraints of the scaffold – thus, in scaffolded learning a student may successfully solve a problem, but not move beyond the problem (Kapur, 2008; Kapur & Kinzer, 2009; Pathak et al., 2008). Research also shows that students in the PF treatment showed greater self-efficacy than students in the control groups. PF suggests that through using un-scaffolded learning a student may develop more flexible and adaptive learning in the long run.

Methodology

The study on PF will use VS. VS is a scenario based MUVE, which is set in 19th century Singapore and is based on historical information about several disease epidemics during that period. The students are transported back in time to help the Governor of Singapore, Sir Andrew Clarke, and the citizens of the city try and solve the problem of what is causing the illnesses and to develop appropriate inquiry skills such as defining the scope of the problem; identification of research variables; establishing and testing hypothesis and presentation of findings. Students will be exposed to either a low structure sequence (LSS or PF) or a high structure sequence (HSS) of inquiry activities.

The participants in the study will be drawn from students studying scientific inquiry in years 7 – 9 at a selective government high school in Sydney. The trials will commence in February 2010. The research study will have two phases, and will be held across six, 45 minute science classes (Table 1). Students will complete paper based inquiry activities.

In the first phase of the study the students in the LSS group will complete a low structure activity, followed by a high structure activity, in the following lesson they will complete a low structure activity. The students in the HSS group will complete a high structure activity followed by a second high structure activity, in the following class students will complete a low structure activity. This cycle will be repeated in Phase 2. The research design also allows for a variation, or phase three, that will allow the students in the HSS to participate in a LSS treatment, so that all students are able to benefit from the PF strategy.

Table 1: The research design

Phase		Phase 1 – Replace the wells		Phase 2 – Change the Coolies practices		
Class	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
HSS	Pre test Orientation	HS HS	LS Mid test	HS HS	LS	Post test Interviews
LSS (PF)	Pre test Orientation	LS HS	LS Mid test	LS HS	LS	Post test Interviews
Variant Phase 3			LS	LS HS	LS	

The research will use mixed-methods of data collection. Quantitative data taken from pre, mid and post tests will be used to measure students overall learning outcomes. The post tests will include a range of activities to measure close, near and far transfer. Students will be tested in VS for close transfer, they will complete an inquiry activity in another virtual space for near transfer and they will complete a paper-based inquiry activity to gauge far transfer. As yet, research into MUVEs has shown little success in transfer from a virtual environment to another domain.

Several qualitative data collection strategies will be used. These include interviews, questionnaires and verbal communication analysis. The interviews and questionnaires will be used to gain an understanding of students' and teachers' responses to the MUVE. Verbal communication analysis will be used to analyse communication between group members. The benefits of using verbal communication analysis to interpret data gathered in educational technology research activities are gaining recognition due to the insights into learner processes that can be obtained through analysing verbal communication (Mazur, 2004; Mazur & Lio, 2004; Steinkuehler, 2006). Video, audio and screen capture technology, such as MORAE, will be used to record the students while they interact with the virtual environments in their groups. Screen capture software can capture online chat, screens and can provide pertinent information into what aspect of the environment the learners are focusing on (Mazur & Lio, 2004). Through a thorough analysis of the verbal interactions a more detailed understanding of the processes used in engaging with LSS and HSS treatments in a MUVE can be obtained.

Final considerations

This paper is not suggesting that instructors move away from structuring activities, rather it suggest that in a supportive learning environment students can benefit from reaching an impasse. Hence, the issue is not whether to structure, but when and how to structure (Azevedo & Jacobson, 2008). That is, a degree of structuring is needed, but allowing students to engage with a problem without structuring in the initial stage of the activity may encourage the activation of non-domain specific knowledge and recognition of gaps in knowledge.

This deeper understanding of the problem increases the domain knowledge and problem solving skills. Reaching an impasse in a supportive environment permits students to explore the problem domain, engage with the problem using their experiences and exhaust possibilities without consequence. While much of the research in this field focuses on improved test scores, this research focuses on the processes of student learning rather than the product. Verbal communication analysis of learner processes may provide a deeper level of insight into how using initial unstructured activities in a virtual environment may contribute to a deeper understanding of the problem space.

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