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Research paper

Virtual Science Laboratory (Vislab): The Effect of Visual Signalling Principles towards Students' Perceived Motivation

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Abstract

The purpose of this study is to investigate the effect of Virtual Science Laboratory (ViSLab) on visual signalling principles towards students' perceived motivation. Motivation can be identified as a dimension that determines learning success and causes the high failure rate among online learners, especially in VR environments. Cognitive load researchers need to determine the motivational effects of instructional conditions, and identify strategies that maintain students' awareness of the learning materials without their being distracted by the world outside, as well as help out instructional designers to distinguish the power of VR learning environments in enhancing the motivation of learners. The lesson of the science laboratory safety is developed in two different modes, Virtual Reality with Signalling (VRS) and Virtual Reality Non Signalling (VRNS). 2x2 quasi experimental factorial design is adopted in this research. The independent variables were the two modes of presentation. The moderator variable is the spatial ability. The dependant variable is the perceived motivation. The study sample consisted of 141 students. The Instructional Material Motivational Scale (IMMS) from Keller was used to determine students' perceived motivation. ANOVA was carried out to determine if a significant difference occurred between the two groups in their motivation towards instructional materials. The findings of this study showed that the use of Virtual Reality with Signalling (VRS) treatment mode helped pupils perform significantly better than Virtual Reality Non Signalling (VRNS) in learning science laboratory safety. Overall, visual signalling principle needs to be considered in the design and development of Virtual Science Laboratory (ViSLab) to promote more effective learning.

Keywords: *Virtual Reality, Science Laboratory Safety, Signalling Principles, Motivation*.

1. Introduction

Safety is a critical constituent of any workplace as well as in school. Science laboratory has earned a reputation of being highly hazardous place in the school because of the high incidence and fatality rates [1]. Safety and health considerations are arguably as important as the content taught in the school science laboratory, it is because we could not predict where and when an accident will happen.

What are the precautionary steps that schools are taking to ensure a safe environment for students and teachers? It is increasingly important for educators to properly maintain equipment, provide instruction in safety, and adequately supervise students engaged in laboratory activities [2]. Therefore, both technical skills and safety knowledge of all students must always be considered to avoid accidents [3].

In year 2011, Malaysia has made an effort to strongly push for full economic and industrial development has framed the Occupational Safety and Health Master Plan for Malaysia 2015 (OSH-MP15) to establish a safe, healthy and productive pool of human capital towards a sustainable safe and healthy work culture in all places. Schools must be regarded not only as a place to study, but also as a workplace. In the case of schools, the working people are students, teachers, administrative and other support staff. It is required to begin an OSH culture with the younger generation in any country. Unfortunately, students' laboratory practices and attitudes were lacking when traditional approaches to safety training were followed. Therefore, an alternative way, such as learning via VR technology expectantly can gain students' motivation to learn science laboratory safety.

VR can best be described as a way for humans to visualize and interact with the artificial 3D environments created using computer graphics [4]. Moreover, VR enables converting the abstract into concrete by giving perspectives on processes that are impossible to perform in the real world [5, 6]. As a result of using VR technologies, learner's cognitive will move from representational learning to conceptual learning through the experiential learning process [7, 8].

2. Visual Signaling Principles

According to Mayer [9] cognitive theory of multimedia learning, signalling is a technique for reducing extraneous processing because it provides guide what the learner pays attention to (the process of selecting) and can help the learners to mentally organize the key material (the process of organizing). Signalling is a technique that can help learner to solve the problems when the lessons having too much extraneous material by draw learners' attention towards the essential material. Learners learn more deeply from a multimedia message when cues are added that highlight the organization of the essential material. The rationale for the signalling principle is that people will learn more efficiently if the lesson is designed to call their attention to the important material in the lesson and how it is organized. Table 1 showed common features of visual signalling.

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Table 1: Common Features of Visual Signalling [9]

Feature	Examples
Arrows	Arrows point to the left, right, bottom and top of the object
Distinctive colour	Use the colour to show the direction or particular component
Flashing	A particular component on the system flashes
Pointing gestures	An on screen agent points to a part of the system
Graying out	When a particular component is being described, it is shown in a "magnifying glass" and the rest of the picture is grayed out

However, according to Mayer [9], signalling adds no new information and it is consistent with the information-delivery view of learning, in which learning involves adding presented material to memory. The signs might even disrupt learning because they are redundant. Moreover, concerning boundary conditions, there was preliminary evidence reports that the signalling principle may apply most strongly when the learner might otherwise be overwhelmed with extraneous processing—such as, for low knowledge learners rather than high knowledge learners [10], and when the display is complex material rather than simple material [11] or when it is used sparingly rather than excessively [12].

3. Motivation

Motivation can be identified as a dimension that determines learning success and causes the high failure rate among online learners, especially in VR environments as VR is a new challenge to cognitive load researchers to investigate the motivational effects of instructional conditions and help instructional designers to predict which instructional configurations will maximize learning and transfer [13]. Pintrich [14] also highlights the role of motivation in promoting and sustaining self-regulated learning tied to better academic performance. His study proves that three general types of motivational beliefs: self-efficacy, task-value and goal orientation predict self-regulation.

Besides, VR provides feedback at once, which leads to reductions in learning time [15]. This is very likely to be main aspects in making students feel more confident on top of leading to better attitudes towards learning. Such feedback reduces student displeasure and provides a sense of performance [15]. The feedback and self-pacing aspect of VR is not only beneficial to students, whereas, teachers also benefit from the VR program. This frees them up to provide more individualized facilitate for students with particular needs [15], which in turn benefits students with special needs and who are at risk.

4. Virtual Science Laboratory (VISLAB)

In this study, the researcher will design and develop a Virtual Science Laboratory (ViSLab) to create a virtual environment for teaching science laboratory safety through customize simulations of science laboratory layouts, dynamic process operations and comprehensive virtual environments and allow users to move within the Virtual Science Laboratory (ViSLab), making operational decisions and investigating processes take a quick look. The consequences of correct and incorrect decisions are sent instantaneously back to the trainees, giving them the opportunity to directly learn from their mistakes [16].

ViSLab provides the advantage of a 3D interface with near real-world representation for applying learning-by-doing and case-based reasoning approaches. The content covered in the ViSLab includes chemical and biological hazards, electrical, fire control, flaming, cut, handling glassware, personal protective equipment and physical safety. The objective of ViSLab is to combine safety content with programming to create an interactive, cognitive engagement and multimedia learning. It is believed that these three factors can influence learning via visualization in line with principles associated with a mental model. Figure 1 showed screen fire happen in the ViSLab.

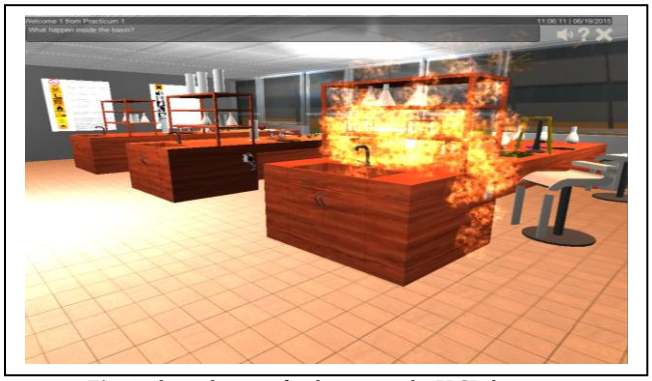


Fig. 1: showed screen fire happen in the ViSLab.

5. Materials and Methods

The research design which will be used in this study is non-equivalent control group of quasi-experimental design 2x2. The factors of the design were two versions of presentation mode: VR with Signalling (VRS) and VR non-Signalling group (VRNS) with different levels of Spatial Ability.

5.1 Research Purpose and Hypothesis

In the light of the above discussion and the review of related literature, it is understandable that using visual signalling principle in the learning of science laboratory safety has a positive effect on academic success, motivation and other variables. The main purpose of this study is to investigate the effects of the visual signalling principle on students' perceived motivation towards VR environments. Thus, the study seeks answers to the following research questions:

Is there any significant difference in students' perceived motivation using Virtual Science Laboratory (ViSLab) with two different presentation modes (VRS & VR NS).

5.2 Population and Sample of Study

There were 141 samples involved in this research study. The respondents had been taught laboratory safety concept and possessed a fundamental knowledge of laboratory safety. The two programs were saved on the computer and then the two treatments were given numbers (VRS treatment - no.1, VRNS treatment - no.2). All the subjects were randomly assigned to one of the two modes of courseware (VRS and VRNS).

5.3 Variables

The independent variables were the multimedia instruction employed to teach Science Laboratory Safety. The two instruction methods employed were the VR with signalling (VRS) and VR with non-signalling (VRNS). The dependent variables were the students' achievement score, Mental Effort Rating Scale and motivation score. The moderator variables were Spatial Ability. Students scoring above the group mean of the Space Relation Test were classified as the High Spatial Ability (HSA) students and while those scoring below the group mean of the Spatial Ability Test were classified as the Low Spatial Ability (LSA) students.

5.4 Research Instruments

The Instructional Materials Motivation Scale (IMMS) measures the subject's motivation towards the courseware developed using

VR in the learning of science laboratory safety. Their responses can range from 1 (strongly disagree) to 5 (strongly agree). The statements are arranged in such a way that a response of 5 (strongly agree) could mean a high or low level of motivation. Thus, during analysis, where a response of 5 indicates low motivation, the scale will be reversed so that a 5 will always indicate high motivation.

6. Results

An ANOVA was conducted to compare the effects of the two presentation modes on the students' perceived motivation. This analysis was to determine if there was any statistically significant difference of the dependent variable (perceived motivation) between the two presentation modes (VRS & VRNS).

The descriptive statistic in Table 2 showed the mean and standard deviation of the IMMS score for the two learning presentation modes. As illustrated in Table 5.31, the IMMS mean score for VRS (*M*=113.97, *SD*=20.75) was slightly higher than VRNS (*M*=106.27, *SD*=18.23).

Table 2: Descriptive Statistics of Perceived Motivation for Two Presentation Modes

Mode	Mean	Std. Deviation	N
VRS	113.97	20.75	68
VRNS	106.27	18.23	73
Total	109.99	19.79	141

Levene's Test was performed to verify that the error variances of student's perceived motivation were equal across the group. The results were shown in Table 3. The significant value [F(1,139)=0.537, *p*=0.465] indicated that the difference was not significant. Therefore, the variances in IMMS score were equal across the group.

Table 3: Levene's Test of Equality of Error Variances

F	df1	df2	Sig.
.537	1	139	.465

Table 4 indicated the results of the ANOVA test of statistical significance on the differences observed in the mean scores of the IMMS score with the value *F*(1,139)=5.494, Mean Square =2085.510, and *p*=0.021. As a result, the hypothesis of this study was rejected. There was a significant difference in students' perceived motivation using Virtual Science Laboratory (ViSLab) with two different presentation modes (VRS & VRNS).

Table 4: ANOVA Analysis of Students' Perceived Motivation

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2085.510	1	2085.510	5.494	.021
Within Groups	52768.462	139	379.629		
Total	54853.972	140			

7. Discussion

Motivation can be identified as a dimension that determines learning success and causes the high failure rate among learners, especially in VR environments as VR is a new challenge to cognitive load researchers to investigate the motivational effects of instructional conditions and help instructional designers to predict which instructional formations will maximize learning and transfer [13]. The Instructional Materials Motivation Survey (IMMS) [17] based on the ARCS motivation model was used to gather information related to students' motivation towards the instructional design; it considers four motivational factors: attention, relevance, confidence, and satisfaction.

From the research study, the results disclosed that there was a significant difference students' perceived motivation using Virtual Science Laboratory (ViSLab) with two different presentation modes (VRS & VRNS). Hence, the result showed that perceived motivation for students using VRS was attained significantly higher score than VRNS in the learning of science laboratory safety.

There are several possible reasons for this result: First, the possible reason for the significant positive effect of VRS on students' perceived motivation might because of signalling principle reduce extraneous processing because it provides clues to the learner about what to attend to and how to organize it. Secondly, signalling also can help the learner to solve the problems when the lessons having too much extraneous material by draw learners' attention towards the essential material [9]. Thirdly, without guidance on how to carry out appropriate cognitive processing, the learner is more likely to engage in extraneous cognitive processing such as processing extraneous material and trying to organize it with the rest of the material. Finally, according to Mayer [9], signalling can help guide what the learner pays attention to (the process of selecting) and can help the learners to mentally organize the key material (the process of organizing).

This is in line with the research findings by Awaatif [18], on a research on the effectiveness of signalling principles in VR learning application to increase students' perceived motivation in Islamic funeral rites with different space relationship. The study discovers that students exposed to the VR with Signalling mode significantly more motivated than the students exposed to the VR without Signalling mode. Besides, in the research study of Melchor, Ing, & Cristina [19], they have reached a satisfactory motivation level and positive performance, which is reflected in motivational factors really suitable using VR learning environment for learning purposes.

More to the point, from the result of Angela, María, & Carlos [20] study, they concluded that the positive impact of VR on motivation leads students to achieve higher levels of engagement in learning activities with less cognitive effort. Xie, Durrington, & Yen [21], investigated the relationship between the students' motivation for learning and the specific use of a specified interactive tool which is found in the majority of virtual reality environments. The investigation discovered a significant relationship between motivation and the students' participation in the asynchronous discussions in an online course.

As a result, the visual signalling principle should make into consideration when designing courseware, as it can create a motivational aspects of learning environments to stimulate and sustain students' perceived motivation to learn.

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