Effects of interactive animation on learning performance in a static equilibrium topic of university Physics for freshmen with different levels of prior knowledge

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Abstract

As the mobile technology has advanced in recent years, the penetration rate of smart phones on college campus has reached one hundred percent. This study features a university Physics curriculum integrating the inquiry-based learning with the use of learners' smart phones. The purpose is to investigate the effects of interactive animation on learning performance in a static equilibrium topic of Physics class for freshmen with different levels of prior knowledge. A quasi-experiment design is employed. The participants are freshmen from one university in Taipei City of Taiwan, with an effective sample size of 64. A one-way ANCOVA statistical analysis is administered to evaluate the learning performance. The results show that learners using their own smart phones to interact with the animation lectures outperform their counter group, based on the assistance of the in-time and constructive support.

Keywords: inquiry-based learning, interactive learning, animation, university Physics

Introduction

The overwhelming popularity of mobile devices such as smartphones and tablets has increased the interest in mobile learning[1]. The integration of digital learning with mobile technology has been proved to lower the barrier of teaching and overcome the space and the time constraints in the traditional teaching models[2], therefore moving students from the passive receivers of knowledge to active learning roles[3]. However, the limited resources of finance and laboratory facilities could be a serious burden, especially for educational institutions with less funding and resources.

Even nowadays mobile devices have become increasingly powerful and extremely popular among college students, research involving the integration of mobile learning into educational laboratory activities remains largely unexplored. In addition, appropriate pedagogy is essential for fostering students' conceptual understanding and inquiry ability. As an instructional model, inquiry-based learning (IBL) centers learning on answering a central question or solving a particular problem[4].

Our study aims to verify the effects of interactive animation environment under the IBL approaches on learners' performance in a university's static equilibrium experiment class. We integrated the video lectures in the mobile device in order to enhance learner-content interactions in university's Physics class. This interactive media aids in the visualization of concept and provides the student-centered learning environment. The study explores a research question as: Is there any significant difference in learning performance in different digital learning environment, namely interactive animation vs. static graph, for freshmen students in the Physics classroom?

Literature review

A. Mobile inquiry-based learning

IBL makes learners more critical thinkers and helps them to develop their own ability to learn in complex environments[5]. The academic content-learning occurs in the process as students work towards finding solutions. Moreover, mobile technology proves to be a suitable support for this learning process[6][7]. Mobile IBL allows teachers to reinforce curriculum content and helps students to build skills by reaching a high level of thinking.

B. Interactive learning and animation

Being compared to the only-reading content, the interactive video lectures prove to be able to provide learners with timely constructive support so as to produce effective learning performance[8][9], and hence are increasingly adopted in the modern learning contexts[10]. One instance of video instruction is animation, in which the objects appear to move continuously. In literature, a number of studies have been conducted to investigate the effect of animation vs. static graphic displays in the context of education[11][12]. An overall positive effect of animation appearance over static graphic visualization was found. This motivated more researchers to show that the dynamic visualization lectures have obvious learning advantages.

Methods

A. Participants

The experiment employed a quasi-experimental design. The participants were 68 first-year students from the College of Engineering of one university in Taipei City of Taiwan. They were randomly assigned into one of the two groups, namely static graph and interactive animation. Each group has 34 students. After excluding those who did not complete the whole process and those extreme score values, we have 32 students in each group. The static graph group has 6 female students and 26 male students, while the interactive animation group has 5 female students and 27 male students.

B. Research design

This research effort aims to develop mobile learning curriculum for supporting students' science inquiry. The design is based on the theory of inquiry-based learning (IBL). It establishes connections between acquisition of new knowledge and the application of knowledge.

Four learning activities are developed based on a combination of curriculum content outlines and the projected inquiry abilities including: making a claim, using evidence, and describing the reasoning process. These activities were with embedded conceptual and inquiry questions.

Activity 1 intended to engage learners on the topic according to their everyday life experience about forces. Four major types force and torque were then introduced, which pave the way to comprehending the transitional equilibrium (Activity 2) and rotational equilibrium (Activity 3). for the following activities. Finally, an elaboration question is adopted in Activity 4. It provides chances for the learners to manipulate the data, to explore patterns with data, and lastly to make claims based on the data.

This experimental process lasts for 180 minutes. It includes 10-minute pre-activity description, 50-minute pretest, 15-minute Activity 1, 15-minute Activity 2, 15-minute Activity 3, 15-minute Activity 4, and lastly a 60-minutes posttest to measure the learners' conceptual knowledge and inquiry ability.

The pretest is a test regarding kinematics of Physics, used as a measure of learners' prior knowledge. The posttest is to evaluate learners' learning performance of this lecture on static equilibrium. Before this experiment, both test's questions and answers had been reviewed and verified by two experienced university professors with 20 and 25 years of experience in teaching university Physics.

C. Tools and development

The Microsoft Power Point software provides visualized edit interface and sufficient functions so that allows the developer to create interactive environment. In this study we use this software by using a personal computer to design two sets of lecture materials, namely interactive animation and static graph. The developed files are loaded and can be displayed on android smartphones or iPhones for lecture use.

As an example, Fig.1 and Fig.2 show some parts of the display of successive stages on smartphones and students' practice in the interactive animation group. The slope is moved up and down to find a critical angle so that the block on the slope does not slide. The forces (presented by vectors) appear one after one until the final stage and allows flexibility for students' interaction.

Fig. 1 Display of successive stages on smartphone in Activity 2

While for the static graph group, the slope is fixed and the forces are all displayed together. The students learn by reading the description just as the traditional lectures.

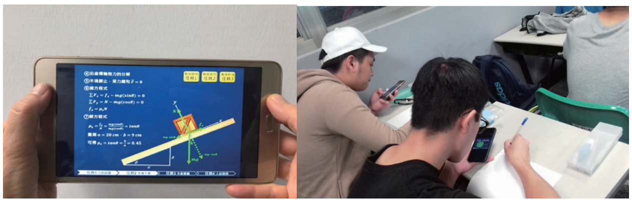

Fig. 2 Example of final stage display on smartphone in Activity 2 and students' learning session in the classroom

D. Data analysis

The experiments employed a quasi-experimental design. A one-way analysis of covariance (one-way ANCOVA) is adopted for the learning performance analysis. In this analysis the independent variable is the digital lecture, which has two levels of static graph and interactive animation. The pretest is as the covariant, and the dependent variable is the learning performance. The collected data are analyzed by using IBM SPSS Statistics-23. The homogeneity of the two groups is tested first, followed by the one-way ANCOVA analysis.

Results and discussion

A. Descriptive statistics and homogeneity test

With regard to the pretest scores, the learners in the static graph and interactive animation groups have almost same level of prior knowledge in kinematics of Physics. As shown in Table 1, the pretest mean scores of the static graph and interactive animation groups are 7.38 and 7.22, respectively. While the original mean scores (posttest) of the static graph and the interactive animation groups are 7.31 and 8.84, respectively, in which the covariate factor is not considered yet.

Table 1
Mean and standard deviation of pretest and posttest

Group	Digital lecture	N	Pretest		Posttest	
			Mean	Std. Dev.	Mean	Std. Dev.
1	Static graph	32	7.38	4.12	7.31	4.12
2	Interactive animation	32	7.22	3.70	8.84	4.32

Then for both pretest and posttest, the homogeneity across groups are verified with p=.436 (in pretest) and p=.942 (in posttest), which have no statistically significant difference at a level of .05, as expected. This is shown in Table 2.

Table 2
Levene's test for homogeneity

Pretest				Posttest			
F	df1	df2	p	F	df1	df2	p
.616	1	62	.436	.005	1	62	.942

Additionally, we did an intragroup regression coefficient homogeneity test. By taking the posttest as the dependent variable, we have the result (p=.674) as given in Table 3 that indicates no statistically significant difference at a level of .05. This means that there is no significant interaction effect between the independent variable (digital lecture) and covariate (pretest).

B. Statistical analysis of learning performance

Once the intragroup regression coefficient homogeneity was verified, we then did the ANCOVA analysis. The effect of the digital lectures on the learning performance (p=.012) reaches a significant level of .05, as revealed in Table 4. Table 5 shows the adjusted mean scores of the static graph and interactive animation groups as 7.25 and 8.91, respectively.

Table 3
Between-subjects regression coefficient homogeneity test

Source	Type III Sum of Squares	df	Mean Square	F	p
Digital lecture	16.577	1	16.577	2.445	.123
Pretest	682.845	1	682.845	100.719	.000
Digital lecture * Pretest	1.211	1	1.211	.179	.674
Error	406.780	60	6.780		
Corrected Total	1142.609	63			

*p<.05

Table 4
ANCOVA analysis report

Source	Type III Sum of Squares	df	Mean Square	F	p	Partial Eta Squared
Pretest	697.102	1	697.102	104.226	.000	.631
Digital lecture	44.346	1	44.346	6.630	.012	.098
Error	407.992	61	6.688			
Corrected Total	1142.609	63				

*p<.05

Table 5
Adjusted means and confidence interval for posttest

Digital lecture	Adjusted Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Static graph	7.25	.457	6.331	8.160
Interactive animation	8.91	.457	7.996	9.825

The interactive animation group comes out with higher achievement in the static equilibrium unit of Physics class when compared to the counter part of control group. This can be the evidence affirming that the use of this type of digital lecture enhances learners' understanding and inquiry ability of Physics. The learners using their own smart phones to interact with the animation lectures outperform their counter group, based on the assistance of the in-time and constructive support. However, one of the possible constraints may be on the learners' familiarity about the smartphones operation.

Conclusions

The modern Physics education stresses on scientific practice such as developing models and explaining the phenomena. IBL focus on the continuous exploration of a topic in which the learners engage in interactive activities so that to generate their understanding. The interactive design is an educational strategy that encourages learners' engagement and active participation.

Animation materials integrated in the curriculum with IBL strategy prove to be a suitable pedagogy for the static equilibrium experiments among the computer-assisted tools in Physics education at the college level, as the forces themselves cannot be observed in reality. This may also relieve the need for some parts of laboratory equipment especially for those institutes with limited finance support. In some sense this improves the cost-effectiveness and portability of platforms to conduct hands-on laboratory activities.

We did not include the teachers' roles as the moderator in this research effort, though teachers are known as core influence in the classroom. In future we may plan to explore more factors related to teachers' effects on students' academic performance in a future study. Besides, the relation between students' achievement and mobile dynamic learning experiences cannot be affirmed based on a single empirical study.

On one hand, similar researches on the creation and the use of mobile animation instructional models can be conducted in other subjects such as Biology and Chemistry. On the other hand, it can also be expanded to a broader range of ages by integrating experimental learning theories to strengthen the exploration in the real-world, so that to promote the learning effectiveness.

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