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Original Research Article

Compared Studies of Orthopedic Learning by Using Augmented Reality, 3D, Video and Conventional Lecture

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ABSTRACT

Three different technologies for medical media were performed in pelvic fracture class, which were conventional video, 3 Dimensional (3D) video and augmented reality (AR). Subjects are 79 medical students in school of medicine, Suranaree University of Technology, Nakhon Ratchasima, Thailand. General demographics were no different. The students did the pre-test by using a 10-question multiple choice tests. Afterward they were randomly separated into 4 groups which studied 30 minutes content in 4 approaches as conventional lecture, VDO, 3D VDO and AR lecture. The students were did the same tests. Learning effectiveness is the change in scores from pre- and post-tests. The students were asked for their satisfaction in terms of understanding, enjoyment, and attractiveness.

The results shown that the pretest score was the same while there were differences of post-test score means among 4 learning methods (p-value, <0.001). Effectiveness: use of conventional or VDO lectures provided higher effectiveness than AR or 3D lectures. Understanding: conventional group was the highest score, followed by AR group, VDO and 3D VDO, respectively. Enjoyment: AR lecture was the highest, followed by VDO, conventional lecture and 3D VDO, respectively.

Attractiveness: AR lecture gave the highest and significant higher scores when compared to VDO lecture but no significant differences of the scores when compared to 3D lecture or conventional lecture.

In the new technologies, AR lecture is the most attractive, funniest and enjoyment in the learning for medical student. However the limitation of AR lecture is about the detail in explanations. 3D lecture is still a new promising star for developing. From the study the attractiveness of 3D lecture is almost the same as AR lecture. The limitation of 3D lecture is about the focus of the picture when the users use glasses, limit time to use and the side effect of the dizziness.

Key words: computer simulation and new technologies.

INTRODUCTION

In medical studies, media is an important in the knowledge transfer. Learning to teach medical students to meet the objective of the course curriculum, it is essential that teachers must know the knowledge and understanding the role and the importance of the media. Including the ability to select and use the media to teach. The selection criteria for instructional materials are appropriateness, authenticity, interest, organization and balance, technical quality and cost. [(1)] Allen and William studied on the properties of the media for teaching, [(2)] which can cause learning and completed purposes of learning. The result found that lecture is the worst in skill practice and looking for difference.

Demonstration is the worst in fact and visual perception. Real model is best for looking for difference but worst for everything.

Nowadays many new technologies supporting for education are provided, e.g. augmented reality, e-books, tablet, smart phone, smart devices, wearable equipment, distant video conference, streaming virtual reality, [3] location based service, cloud service system, holographic display, 3D video, 360° video, 3D scanning and 3D printing. [4] These technologies enhance student skills in learning, research, exploration, communication, collaboration and socialization. [5] Augmented reality, holographic display, 3D video and 360°video offer more visual information and perspective than the typical video. Tablet and Smartphone are widely used for communication and socialization. The distant communication and collaboration can be easily done by the video conference hardware and software embedded in tablet, smart phone and smart TV. Cloud service system keeps massive learning media. Location based service can be applied in many explorations. Virtual reality technology is a key for the simulation study. 3D printing is used for synthesize a three-dimensional object.

There are many researchers applied the technologies mentioned to the medical study. However there is no study that compared result of using augmented reality, 3D video and video in medical learning with the classical lecture. The researchers used all innovation for improving the satisfaction and enriched multimodal learning environments. There are a lot of researches on augmented reality (AR) that showed extreme advantages for increasing the student motivation in the learning process. [6-11]

Martin et al., 2011 [12] review 10 studies considered the number of articles about AR is increasing but according to the analysis this technology is in their initial stage in education. Augmented reality is considered a successful meta-trend.

Radu, 2012; Radu, 2014 [13,14] reviewed of 26-32 studies that compare students learning by AR versus on-AR applications. The findings on the positive impact are: increased content understanding, learning spatial structures, language associations, long-term memory retention, improved collaboration and motivation. The findings on the negative impact are: attention tunneling, usability difficulties, ineffective classroom integration and learner differences.

Santos et al., 2014 [15] reviewed 87 papers and concluded that there are three main affordances of AR: real world annotation, contextual visualization and vision-haptic visualization. And stated that the three affordances are supported by existing theories like: multimedia learning theory, experiential learning and animate vision theory.

The study considers categories for analyzing the current state and tendencies of AR such as the uses of AR in educational settings as well as its advantages, limitations, effectiveness; the availability of adaptation and personalization processes in AR educational applications as well as the use of AR for addressing the special needs of students in diverse contexts.

Bacca, J. et al. (2014) [16] did a systemic review and found that the main advantages for AR are: learning gains, motivation, interaction and collaboration. Limitations of AR are mainly: difficulties maintaining superimposed information, paying too much attention to virtual information and the consideration of AR as an intrusive technology. AR has been effective for: a better learning performance, learning motivation, student engagement and positive attitudes.

Beier et al [17] used AR in medicine, they used for medical education, surgical simulation and plan, virtual endoscopy and neuro-psychological assessment and rehabilitation. The advantages of virtual endoscopy for medical training have been recognized. They created a virtual reality platform for medical education. The system

only overlays those pieces of information that are necessary. This eliminates the need for the user to immerse in a totally virtual environment and supports the intuitive integration of the information into the setup. This information can be given e.g. by visualization of objects that are actually hidden under the real surface giving the impression of a view inside. In orthopedics field Simulators have shown training benefits in both knee and shoulder arthroscopy. [18,19] Angelina M. et al. [20] used an augmented reality telementoring (ART) platform and showed shorter in learning curve. Dede C. et al [21,22] shown Emerging technologies address core issues of students' engagement, mastery of sophisticated knowledge and skills, learning transfer, and attaining level. Due to limit amount of study of AR in medical studies especially in orthopedic learning and there is less known about the impact of medical AR applications on the student during the learning process. From previous study there is no compare between augmented reality, 3D video, video and normal lecture in medical studies. The purpose of study is to compare result of augmented reality, 3D video, video and normal lecture in orthopedic learning in medical student.

MATERIALS AND METHODS

Participants

79 second year medical students of School of medicine, Suranaree medical institute, Suranaree University of Technology of academic year 2015were invited to participate in the study. The students must voluntary gave their informed consent to attend the study and had not previously participated in any regular courses regarding pelvic fracture.

Learning material intervention

The learning subject is orthopedic course about pelvic fracture. The students were randomized into 4 groups and did the pre-test to establish a baseline with respect to a prior knowledge of the learning topic using a 10 question standard multiple choice test about "pelvic fracture". The test must be completed within 10 minutes. Group 1 received conventional lecture. Group 2 received VDO lecture. Group 3 received AR lecture. Group 4 received 3D lecture. The content of conventional lecture, VDO lecture, AR lecture, for pelvic fracture were the same. The 3D application was composed of the special monitor and 3D glasses. The 3D lesson material was developed by Suranaree University of technology. The AR application was an android application developed by Suranaree University of technology. Using AR, virtual information could be linked from the marker, thus providing an additional layer of information to the students.

The students were instructed to read and learn about the use of learning material for 10 minutes. During the study, staffs were placed in every rooms for answer the questions about using material and observe the students. The learning "pelvic fracture" topic was 30 minutes in each group. Each study group was conducted in a separate room from each other in the same time. After 30 minutes, the students were again tested to complete the previous standard multiple choice tests for 10 minutes.

Evaluation tools and outcome measurement

Learning effectiveness were measured using a paper-based multiple choice test, consisting of 10 questions with 5 choices and one correct answers. The test questions and related answers were created by a member of the staff of the orthopedic department. Another two members of the staff evaluated the multiple choice test with respect to comprehensibility, difficulty, and time consumption. The contents provided in lecture were reviewed to determine whether the content necessary for answering all questions was sufficiently covered by two orthopedists. Learning effectiveness of each individual student was defined as the change in scores on the pre- and post-tests.

The students were also asked to provide information about their satisfaction in terms of understanding, enjoyment, and attractiveness which they felt about the

teaching method using 10-point satisfaction scales.

Statistic method: Baseline characteristics, including gender, age, cumulative GPA and pre-test score among groups were compared using ANOVA or chi-square test. ANOVA was also used to compare post-test score, effectiveness, understanding, enjoyment and attractiveness among study groups. If there was significant difference found, Bonferroni test was used for a pair wise comparison of the means in order to determine which means are significantly different. A difference was considered significant at a *p*-value less than 0.05.

RESULTS

Seventy-nine second year medical students were randomized into the 4 study groups, 20, 20, 20, and 19 students for conventional lecture, VDO lecture, AR lecture, and 3D lecture group respectively. There was no different of age, gender, cumulative GPA, English grade and pre-test score among study groups as figure 1.

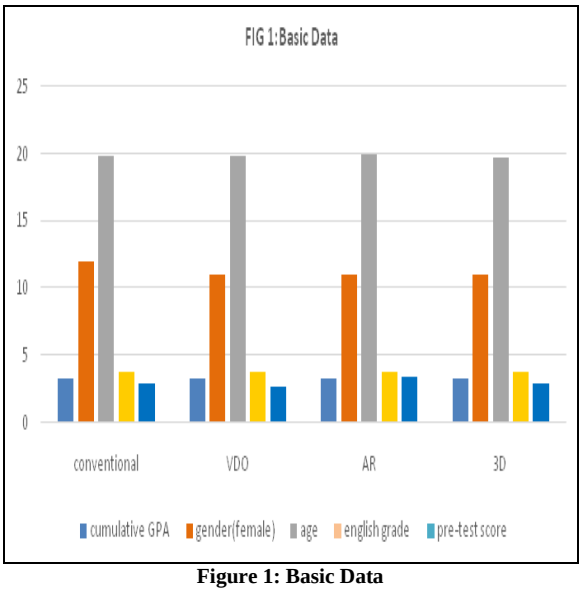


Figure 1: Basic Data

Table 1: Baseline characteristic and study results

	Lecture type				
	Conventional (n=20)	**VDO(n=20)**	**AR(n=20)**	**3D(n=19)**	***p*-value(among groups comparison)**
Baseline characteristic					
Female, n (%)	12 (11.4)	11 (11.4)	11 (11.4)	11 (10.8)	0.986
Age (year)	19.80 ±0.52	19.90 ± 0.45	19.95 ±0.39	19.68 ±0.48	0.296
CumulativeGPA	3.36 ± 0.39	3.35± 0.36	3.36 ± 0.35	3.36 ± 0.39	0.944
English grade	3.83	3.85	3.79	3.83	
Pre-test score	2.9±1.52	2.65±1.39	3.4±1.27	2.95 ±1.65	0.439
Post learning					
Post-test score					
Mean ± SD	8.6 ± 1.43	6.9 ± 1.83	5.95 ± 1.27	5.58 ± 2.01	<0.001
Post Hoc Test *p*-value					
vs VDO	0.011*	NA	NA	NA	
vs AR	<0.001*	0.444	NA	NA	
vs 3D	<0.001*	0.091	1.000	NA	
Effectiveness (Δpost and pre-test scores)					
Mean ± SD	5.7 ± 1.95	4.25 ± 2.27	2.55 ± 1.47	2.63 ± 2.11	<0.001
Post Hoc Test *p*-value					
vs VDO	0.136	NA	NA	NA	
vs AR	<0.001*	0.048*	NA	NA	
vs 3D	<0.001*	0.074	1.000	NA	
Pre-post test within group comparison					
Pre-vs post-test score: *p*-value	<0.001*	<0.001*	<0.001*	<0.001*	
*** Statistical significant.**					
Understanding score					
Mean ± SD	6.7 ± 2.77	4.3 ± 2.36	6.3 ± 2.45	3.37 ± 2.41	<0.001
Post Hoc Test *p*-value					
vs VDO	0.020*	NA	NA	NA	
vs AR	1.000	0.082	NA	NA	
vs 3D	0.001*	1.000	0.003*	NA	
Enjoinment score					
Mean ± SD	4.65 ± 2.25	5.30 ± 3.13	7.30 ± 2.70	3.89 ± 2.62	0.001
Post Hoc Test *p*-value					
vs VDO	1.000	NA	NA	NA	
vs AR	0.016*	0.129	NA	NA	
vs 3D	1.000	0.647	0.001*	NA	
Attractiveness score					
Mean ± SD	5.3 ± 2.34	3.9 ± 2.79	7.9 ± 2.71	6.58 ± 1.98	<0.001
Post Hoc Test *p*-value					
vs VDO	0.472	NA	NA	NA	
vs AR	0.009*	<0.001*	NA	NA	
vs 3D	0.673	0.007*	0.606	NA	

Post-test score

The results shown in table 1 that there were differences of post-test score means among 4 learning methods (ANOVA: p-value, <0.001). Post-hoc test results shown that conventional lecture had significant higher post-test score (Mean ± SD, 8.6 ± 1.43) when compared to use of VDO, AR, or 3D lectures (Mean ± SD, 8.6 ± 1.43,5.95 ± 1.27, and 5.58 ± 2.01, respectively) while there was no difference of post-test score means between VDO lecture *vs* AR lecture, VDO lecture *vs*3D lecture, or AR lecture *vs* 3D lecture. In other words, use of conventional lecture gave the best post-test score. However, the means between post-test and pre-test scores were statistically different from each other for all groups (Pair t-test: *p*-value, <0.001 for all groups).

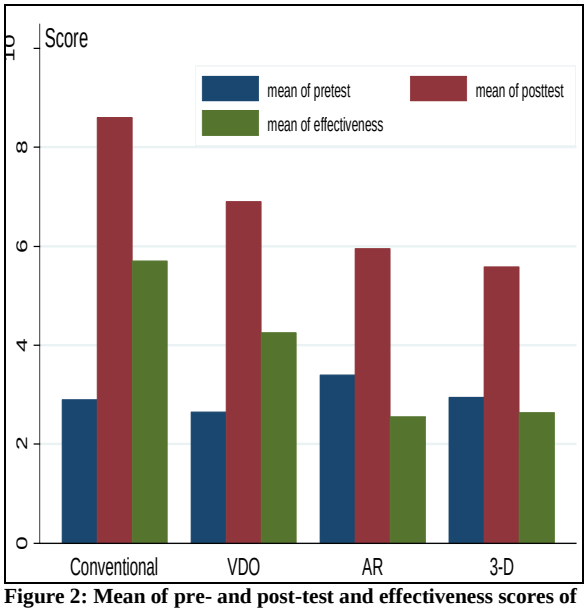
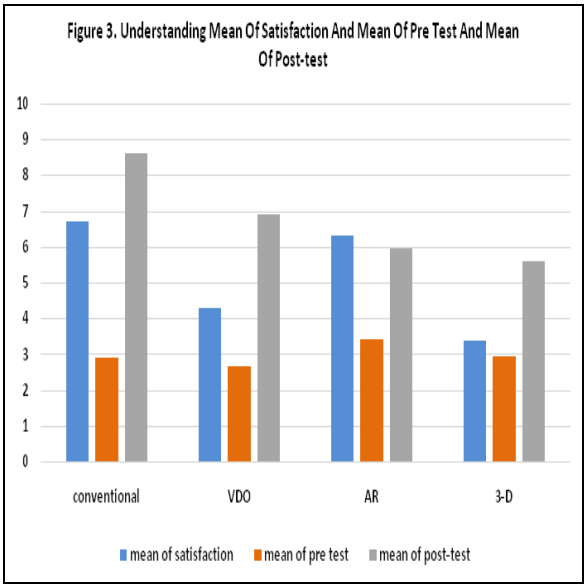


Figure 2: Mean of pre- and post-test and effectiveness scores of each study group.

Effectiveness

As figure 2 the results shown that there were differences of effectiveness among 4 learning methods (ANOVA: p-value = <0.001). Post-hoc test results shown that conventional lecture gave significant higher effectiveness (Mean ± SD, 5.7 ± 1.95) compared to use of AR (Mean ± SD, 2.55 ± 1.47) or 3D (Mean ± SD, 2.63 ± 2.11) but there was no significant difference of effectiveness when compared to VDO lecture (Mean ± SD, 4.25 + 2.27). The learning effectiveness from VDO lecture was significant higher than AR lecture but was not different from 3D lecture. In other words, use of conventional or VDO lectures provided higher effectiveness than AR or 3D lectures.



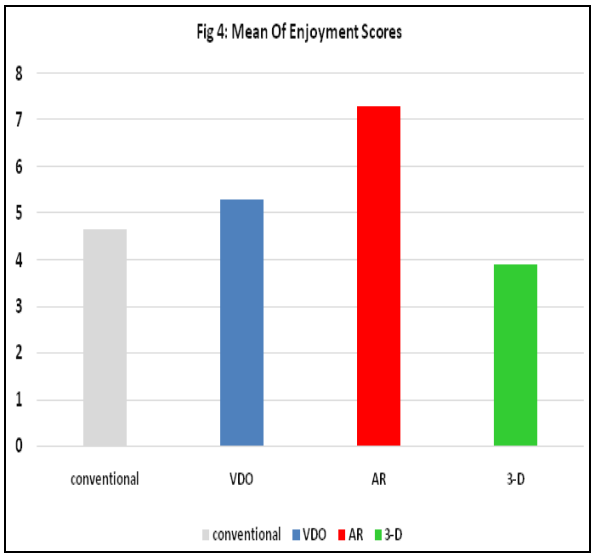
Understanding

The results in figure 3 shown that the satisfaction score in terms of understanding was highest in conventional group (Mean ± SD, 6.7 ± 2.77), followed by AR group (6.3 ± 2.45), VDO lecture group (4.3 ± 2.36) and 3D group (3.37 ± 2.41), respectively. The mean score among study groups were compared and found that there were significant differences among them. The conventional lecture group had significantly higher scores than the VDO lecture and 3D lecture groups but no significant scores when compared to AR group. The mean score in AR group was significant higher than 3D group but not different when compared to VDO group.

Enjoyment

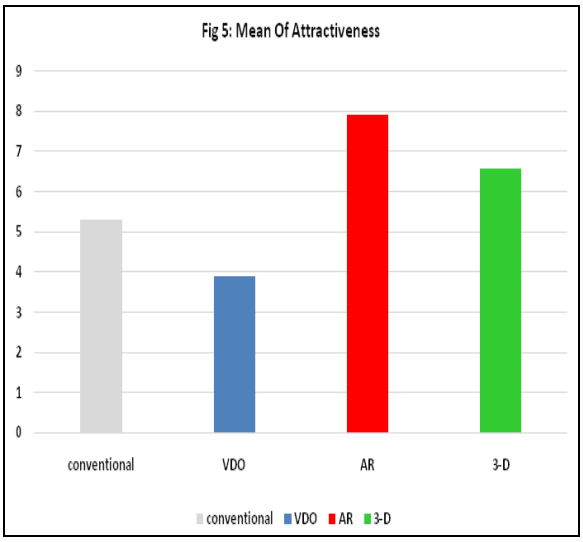
The results in figure 4shown that mean of enjoyment scores in AR lecture was the highest (Mean ± SD, 7.30±2.70), followed by VDO lecture (5.30±3.13), conventional lecture (4.65 ±2.25) and 3D lecture (3.89±2.62), respectively. However, there were no significant differences

between each pair of the teaching method, excepted for AR lecture *vs* conventional lecture and AR lecture *vs* 3D lecture.



Attractiveness

As figure 5 the result shown AR lecture gave the highest attractiveness (Mean ± SD, 7.9 ± 2.71) and significant higher scores when compared to VDO lecture (Mean ± SD, 3.9 ± 2.79) but no significant differences of the scores when compared to 3D lecture (Mean ± SD, 6.58 ± 1.98) or conventional lecture (Mean ± SD, 5.3 ± 2.34). The lowest mean of attractiveness scores was VDO lecture which significant lower than AR and 3D lectures but not different when compared to conventional lecture.



DISCUSSION

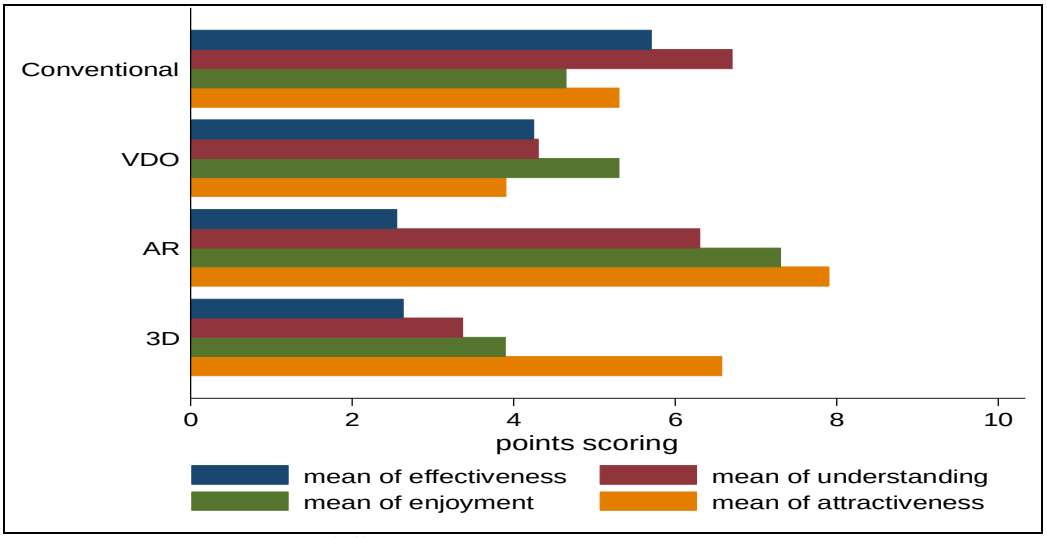


Figure 6: Means of effectiveness, understanding, enjoyment and attractiveness.

For the study, a mobile AR learning environment was developed for almost realistic fracture pattern simulations in orthopedics lecture, where learners become emotionally involved in their learning process. The use of mobile devices, especially when augmented reality comes into reality, can considerably change the learning experience as well as shift it to an entirely new level of learning, which that experiences are simply not possible in a conventional learning setting.

From the result in figure 6we found that AR is very attractive and fun. AR gave the highest attractiveness (Mean ± SD. 7.9 ± 2.71) and significant higher scores when compared to VDO lecture (Mean ± SD. 2.9 ± 2.79) but no significant differences of the score when compared to 3D lecture (Mean ± SD. 6.58 ± 1.98) or conventional lecture (Mean ± SD. 5.3 ± 2.34) The lowest mean of attractiveness scores was VDO lecture which significant lower than AR and 3D lectures but not different when compared to conventional lecture.

From the enjoyment the results shown that mean of score in AR lecture group was the highest (Mean ± SD. 7.30 ± 2.70) followed by VDO lecture group (5.30± 3.13), conventional lecture group (4.65± 2.25) and 3D group (3.89±2.62) respectively. However, there were no significant differences between each pair of teaching method. Excepted for AR lecture Vs conventional lecture and AR lecture Vs 3D lecture.

But the most interesting in this study is about poor result of 3D lecture. We founded that student complained about the focus of the glasses when the position of the sitting is not in the middle of the monitor. The complaint was about the dizziness when the lecture passes 20 minutes, the sharpness of the picture. In the present the 3D technologies is still limit usage from the side effect.

CONCLUSION

In the new technologies that emerge for today, AR lecture is the most attractive, fun and enjoyment in the learning experience for medical student. But the limitation of AR lecture is about the detail of the lecture in explanations. 3D lecture is still a new promising star for developing. From the study the attractiveness of 3D lecture is almost the same as AR lecture. The limitation of 3D lecture is about the focus of the picture when the user use glasses, limit time to use and the side effect of the dizziness, nausea, oculomotor and disorientation. [(23)] If we can develop 3D technology and AR technology that eliminate the limitation of uses, we believe that these technologies will be the most attractive and effective for learner.

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