Basic Refinery Training Courseware in Enhancing Technical Employees' Visualization Skills

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Abstract—Various research has been conducted to enhance the employees' visualization skills in different areas and the importance and the role of visualization skills towards the employee's achievement, especially in the industry such as manufacturing, medical, oil and gas field, and many more. To improve visualization skills, the use of effective training methods and tools should be applied to facilitate and enhance the understanding and performance in general, in a way to help them solve problems at the workplace. Thus, the aim of this paper focuses to the attention on the practical use of augmented reality (AR) with the ability of digital mobile application in the crude oil refinery process within the oil and gas industry environment, describing the potential and the effectiveness of the technology to enhance the visualization skill among the technical employees. This study used Basic refinery courseware that can be accessed via digital network to give an interactive training experience that can enhance technical employees' visualization skills. This courseware shows the positive effect and impact on technical employees' visualization skills and performance based on the results. The results have also shown an increased motivation, making them more cooperative and developing visualization skills more quickly. Considering these results, it can be concluded that Basic Refinery training courseware based on augmented reality application is an effective and beneficial tool to be applied in training programs among the workplace's technical employees.

Keywords—basic refinery, augmented reality, visualization skills, learning courseware, technical employee

1 Introduction

Visualization is an effective method for learners to attribute concepts and to establish correlations between concepts [1]. It includes features to make an object, action, process or activity visible. [2] highlighted the objective of visualization is when human use visual perception of information to enhance of cognitive abilities. It is capable of processing visual signals quickly, and also advanced information technology has turned the computer into a powerful tool for managing digital information. Visualization improves human's abilities about abstract thinking [1]. Acquiring figure and dimension concepts affects human's thinking worlds and cognitive development positively. The main intention of visualization is to ensure students learning on how to think visually by using visual models to improve their understanding on the topics. However, the training tools that is currently being used does not support the enhancement of technical employees' visualization skills.

Many of the technical employee are facing the problem in processing and understanding the visual information or developing mental images at work place. Technical employees are facing difficulty to understand well or better on the current training module because the current approach and tools being used limit the ability to understand the detail complex process, as it is viewed in conventional 2-dimensional and not using latest technology approach, such as AR or Virtual Reality in the teaching and learning approach. This is because the training approach is still relying on conventional teacher-student classroom settings. The trainer's approaches to teaching play an important role in the learning and transfer outcome of trainees [3]. This approach of teaching and learning has been and still being used in many professional trainings.

There are a few interactive methods that can be applied that can involve the trainer and trainees in training actively and simultaneously assess their performance during and after training [4]. In the crude oil refinery industry, lack of visualization skills can affect and lead to the impact of the technical employees' performance and work quality. Therefore, appropriate training with suitable modules should be implemented in the petroleum refinery process to improve the visualization skill and efficiency and quality of technical employees and to supply direct professional training to employees. Thus, the study attempted to respond to the research question, i) is there any improvement on the level of visualization skill among technical employees before and after being exposed to current training module? and ii) is there any improvement on the level of visualization skill among technical employees before and after being exposed to the Basic Refinery Courseware based on AR environment?

Various technology components of information and communication have offered new teaching and learning ways to increase employees' performance in their task. One of them is offering the visualized way of teaching and learning [5]. Visual teaching and learning are essential in today's education for developing critical thinking. Tools for visualization are usually used to enhance the level of learning and develop critical thinking. They also promote some different learning styles that support students' attitude [6]. Many emergent technologies have been acquiring a strong impulse in recent years [7]. One of these emergent technologies is Augmented Reality (AR), which will indeed have a high level of penetration into all our world today, including oil and industry. AR gives the user the ability to see things in the real world that is invisible to the naked eye, and perhaps this technology allows the user to gain a clear view and a better understanding of the process at hand, as well as any technical issues that may occur [8], [9]. Furthermore, usage of AR can be further enhanced with the digital mobile application using smart mobile devices such as handphones, tabs or laptop that can be accessed via the network that provides more flexibility for the user. Thus, the objective of this study is on the application of usage on the augmented reality (AR) in the training of the crude oil basic refinery process within the oil and gas industry environment. From here, the researchers will also study and compare the impact of AR and conventional training method in improving the level of visualization skills among technical employees.

2 Literature review

2.1 Augmented reality

Augmented reality (AR), a modern technology exists when users perceive virtual content anchored in the real world [10]. This technology has positively influenced in various fields such as in education, games, industry, entertainment, tourism, maintenance, navigation, medicine and visualization and can be use in single user and multiuser scenarios. While [11] described that augmented reality is an interactive experience with the real world where the real objects are enhances by computer-generated perceptual information. The internationally recognized series of Horizon Reports claims that new technologies such as AR will lead to a redesign of learning and teaching [12].

Augmented Reality technology is known as combining real-world objects with virtual overlay technology [13]. The overlay of technology on top of what we see offers greater versatility in application and use for a wide variety of applications that, when being used, keep the user tethered to their real environment [14]. It means the virtual objects contain the text, video, audio, and 3-dimensional models used as enhancement and instruction over real-world environments. Basically, augmented reality is a relatively emerging technology applied, whether in the exploration stage for training design or syllabus development. Through the using of 3D objects and views, imaginative media, simulations with different types of interactions it will make it easy to connect the two isolated worlds [15].

According to [16], AR is visualization tool and interactive learning materials with animation, instructions, videos and illustrations. It highlighted that the implementation of AR modern technologies may provide the increasing of motivation, enhances concentration and attention, increases their cognitive experience, and promotes the development of their creative abilities. For instance, in the refinery process of the oil and gas industry, the workers can view at a tank, and access real-time information such as temperature, fluid capacity, pressure, and location as well as the safety precautions in the plant operation, which augmented reality was identified as a technology with huge potential for this process [17]. In production operation, the workers can easily view through a virtual guide on safety procedures, identified in dangerous areas, and show the right equipment to wear during the working hour to prevent any imminent danger. During the process, the technical work has to visualize instructions on the tasks carefully, and therefore with the augmented reality, instructions may give automatically over the real condition and also can conduct the routine operation more safely and conveniently than ever before. The interaction with the augmented reality objects able to improve the understanding and memorization of the learners led to the simplifying of the training process. By creating an image of 3-dimensional objects, using the augmented reality, the trainer will invite and attract the employees' attention, which is quite difficult to hold so long through other tools of training such as traditional training method. Technical workers always have difficulties and limitations on having training inside a plant environment such as the oil refinery process which is exposed to a lot of hazard and safety risks. Usage of AR technology combined with mobile applications such as laptops, smart phones or tabs will provide an alternative of having an effective training using 3D technology with improved training experience and effectiveness.

With this new capability, technical workers can experience an interactive training without having the needs to enter the plant environment as the digital courseware can be accessed from anywhere and anytime via the interactive mobile solutioning.

3 Theoretical framework

This paper utilizes cognitive multimedia theory and constructivist learning theory to guide the evaluation of the effectiveness of Basic Refinery Courseware. The significant of these theories is to guide in choosing appropriate tools or method that was used in order to enhance the visualization skills among the technical employees.

In this study, the researcher applied two main theories by combining the Constructivist Theory [18] and Cognitive Multimedia Learning Theory [19]. Constructivist Theory emphasized the support at the learner's role as an active learner and by allowing them to construct their knowledge, they will ensure experience meaningful learning and therefore increase the ability to relate the knowledge with the reality. The constructivist theory's approach that can be applied to this study is relevant due to the nature of the theory that supports the learner's role as an active learner [20]. The constructivist theory learning approach basically will be applied during the development of Basic Refinery based on augmented reality environment will be done. Therefore, the implementation of the finish product of augmented reality application will be presented in the training classroom that used the constructivist approach.

Cognitive Multimedia Learning Theory described the used in the development of AR courseware which is focusing on the memory and storing process that will enhance the learning process. Besides that, the cognitivist learning theory also being used in the same phase of this study during the development of the teaching aid. This theory is being applied when designing the content of the training courseware in order to accomplish the technical employee's cognitive needs. Cognitive Multimedia Learning Theory by Mayer defined that learner will experience the meaningful learning activities when it involves the combination of words and pictures in the learning rather than words alone. Therefore, the researcher implements this theory in the development of training courseware to determine the content and selecting adequate usage of media with the suitable words to be able technical employees creates an effective mental representation. According to [21] agreed that multimedia learning is a process by which people develop mental content from words and picture. This is due to the elements such as words and pictures as well as audios are well selected and organized dynamically to produce logical mental constructs during the learning activities. This is important to ensure that the design content can enrich and bring in benefits towards the technical employee's mental constructions.

Other theory that related to this study is Cognitive load theory by [22], [23] which this theory is an instructional concept to optimize learning activities based on the human cognitive. According to [24] and [25] in their systematic review has shown that the importance of cognitive load theory in many research in using the multimedia learning. In learning activities, the development of the education tools should produce the educational material or tools that do not overload the limited capacity of working memory [26]. This is because when the learning tools are complex which can lead a risk of overloading working memory [27], [28]. Both cognitive theories were identified as solutions in the training material that instructors or trainers should pursue to optimize technical employees' learning and increase the visualization skills among them.

4 Methodology

This study used a quasi-experimental research design by comparing two different treatments between the training of the technical employees who were given a treatment using new training courseware based on augmented reality environment and the training using the conventional method with the existing training module.

This study involved the evaluation of the effectiveness of the newly developed basic refinery training courseware which uses augmented reality environment. There are two groups involved in this phase that are the control group and the experimental group. Basic Refinery Courseware is used as a training tool for the experiment group consists of 30 technical employees, while the current training module will be used for the control group consists of 30 technical employees as respondents. The research is being divided into pre-test and post-test mode to enable a detail evaluation and comparison to the identified groups (control and experimental), before and after the learning process. At early stage, for both of the groups (control and experimental), a pre-test is conducted to understand and map the current level of visualization skills before going thru a treatment process.

After that, all the identified respondents in the control group will be given treatments which consists of training using current module while the experimental group will go through treatment using the basic refinery training courseware. Once the learning process has been completed, the respondents in both groups will be given post-tests to identify their level of visualization skills after undergoing the treatment for both groups. In this study, the independent variable in the test is the Basic Refinery courseware itself while the dependent variable is the difference in the pre-test and post-test score. The other variable of this part of research is current training module used.

The study used Visualization Ability Test (VAT) developed by the researcher as a survey questionnaire. Pilot study was conducted to measure the validity and reliability of the questionnaire using the Winstep software to construct and content validity. In this study, the questionnaire was designed to investigate the effectiveness of augmented reality training courseware after the intervention. To ascertain the validity of the instrument used for the study, the research instrument focused on Visualization Ability Test (VAT). To determine the internal consistency of the instrument that was utilize for conducted questionnaire, Alpha Cronbach method was used to ascertain the extent of homogeneity of the items of the questionnaire. This method is most suitable kind of reliability for quantitative instruments which is questionnaire where there are series of possible answers for every item [29]. Alpha Cronbach value for the research instrument of Visualization Ability Test was 0.71. The questionnaire is used to obtain and determine the effectiveness of the augmented reality courseware towards the technical employees. These data were analysed using descriptive statistics (Frequency, Percentage) and inferential statistical analysis (Independent T Test) using the application of SPSS software version 20.0.

5 Result

Based on the treatment and intervention given during the training, the analysis results in the experimental group for each employee before and after the use of basic refinery training courseware are obtained. The analysis shows the pre-test and post-test score using basic refinery training courseware. The result of the analysis can be seen in Tables 1 and 2.

Table 1. Descriptive analysis of experimental group

Augmented Reality Courseware	Pre-Test	Post-Test
N	30	30
Range	37.04	25.92
Minimum	22.22	66.67
Maximum	59.26	92.59
Mean	38.7650	81.6040
Std. Deviation	10.09518	6.18732
Variance	101.913	38.283

Table 1 shows the result of descriptive analysis among the experimental group. Based on the table, the experimental group's pre-test achievement result indicates a low score of 38.77. Meanwhile, the average score of the post-test result in the experimental group using augmented reality courseware shows the mean value of 81.60. This is equivalent to an increase of 210.52%, comparing to the result between pre-test and post-test. The sample size (N) was 30 number of participants. The standard deviation was also significantly improved from 10.09 (pre-test) and 6.18 (post-test), while the variance also demonstrated a better value from 101.91 (pre-test) and 38.28 (post-test).

Table 2. Descriptive analysis of control group

Augmented Reality Courseware	Pre-Test	Post-Test
N	30	30
Range	40.74	29.63
Minimum	22.22	40.74
Maximum	62.96	70.37
Mean	41.9550	55.9170
Std. Deviation	8.29650	7.92380
Variance	68.832	62.787

Table 2 shows the result of the descriptive analysis of the control group. Based on the table, the control group's pre-test achievement result indicates a low score of 41.95. Meanwhile, the average score of the post-test result in the experimental group using conventional training courseware shows the mean value of 55.91. This is equivalent to an increase of only 23.74% comparing to the result between pre-test and post-test. The sample size (N) was 30 number of participants. The standard deviation was slightly improved from 8.29 (pre-test) and 7.92 (post-test), while the variance also demonstrated a slightly improved value from 68.83 (pre-test) and 62.78 (post-test).

An independent T-test was performed on both sets of data to determine if there are any statistically significant differences in terms of average mean value between the result of pre-test and post-test both from the experimental and control groups. Table 3 shows the results when a 95% confidence level is being applied. In both independent t-tests, the inferential analysis demonstrated that the p-value for both analyses for the experimental and control group is less than 0.05. It can be concluded that the mean score for the visualization test for both experimental and control groups is significantly different for pre-and post-test.

Table 3. Result of inferential analysis

Independent Test						
t-Test for Equality of Means						
		t	**df**	**p-Value**	**Mean**	**Std. Error Mean**
Exp (pre & post)	Equal Variances Assumed	–19.654	29	<.000	–42.839	2.17963
Con (pre & post)	Equal Variances Assumed	–8.618	29	<.000	–13.962	1.62006
Test of Normality of ControlPre and ControlPost						
	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistics	**df**	**Sig.**	**Statistics**	**df**	**Sig**
ControlPre	.158	30	.053	.960	30	.310
ControlPost	.151	30	.078	.948	30	.150
Test of Normality of ExperimentalPre and ExperimetalPost						
	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**	**Statistics**	**df**	**Sig**
ExperimentalPre	.111	30	.200*	.964	30	.394
ExperimentalPost	.152	30	.078	.981	30	.100

However, as described in Tables 1 and 2, the mean score differences between pre-test and post-test for the experimental group are much more significant (210.52% gain) than the difference of score between pre-test and post-test for the control group (23.74% gain). This result indicates that training using an augmented reality training environment is more useful and impactful in helping technical employees enhance their visualization skills than the conventional teaching method.

6 Discussion

The Visualization Ability Test (VAT) result before and after the training were analyzed and compared. The result had indicated that the incremental value or the gain score of the Visualization Ability Test of the respondents from the experimental group was significantly higher compare to the gain score from the control group. The differences in the gain score were relatively significant and prove a greater impact when using the augmented reality approach to improve the level of visualization skills among technical employees. The use of augmented reality technology and training approach on the newly developed Basic Refinery Courseware has increased interactiveness, understanding, and awareness among the participants when dealing with such highly technical and complex training content. Usage of more video presentations and pictures of plant equipment and process, with the aid of 3-dimensional graphical technology made available in the new training courseware, had provided a practical learning experience that has resulted in significant improvement in the Visualization Ability Test scoring.

Based on this study, the researcher found that the use of Basic Refinery courseware during the training can be seen as a practical approach to improve visualization skills among technical employees. Integrating the multimedia and augmented reality technology and interactive mobile application application in the courseware provides them with a real-world plant refinery experience. The potential of augmented reality technology as a visualization training tool is widely acknowledged in various field. The utilization of multimedia technology as an interactive learning tool in education and training will positively impact the understanding and visualization skills [30], [31]. It also enhances the user's understanding of technology, which oriented towards the interactive learning process. Other than that, [32] identified that multimedia learning could increase achievement in the learning experience. These research results are relevant to the study results by [33], [34] which stated that multimedia learning could help stimulate learning and increase passion, enjoyment and promote high learning motivation. Thus, the Basic Refinery courseware is a tool that combines both approaches to intensify the outcomes desired by the researchers, which is to improve technical employees' visualization skills.

These findings in this study are consistent with [35] finding, which shows a higher score among students in the experimental group compared to the control group. Their study aims to test augmented reality (AR) effectiveness towards students' achievement and self-efficacy in vocational education and training. It was found that the use of AR had a positive impact and showed that the AR application could be effective in increasing students' achievement. Another study also reported a similar finding by [36], where they found that augmented reality technology helps trainees increase their training efficiency. Their study focused on the skill transfer in assembly task using 2D and 3D puzzles while using augmented reality indicates a better skill-transfer than non-AR application. Another study by [37] used augmented reality in a monitor-based system for assembly training task. Both group using a traditional manual, while the other group using an augmented reality application. Results indicated that there is effectiveness on the assembly time when using this technology compared to traditional manual. A study by [38] shows that trainees learn faster using augmented reality than paper-based instruction. This indicates that the respondents are satisfied with the interactive technology of augmented reality, which helps enhance users' learning interest.

The use of AR solutions offers a multitude of potentials for the industry. AR described the enrichment of reality through virtual elements such as information, objects, and interaction possibilities. The trainees or newcomers' technicians and Training Near the Job (TnJ) can use the AR approach and learning environment using 3-dimensional objects to practice the activities related to the operation where costly errors may occur if they used the real-world objects [39]. Integrating AR technologies in training can lead to a significant reduction in costs. It can be stated that AR technologies represent an innovative learning media with interactive mobile application that enables flexible on-demand training directly on the shop floor. AR training is used to train employees and reduce defects and assembly errors, and have a positive economic impact on the company's bottom line.

Virtual objects can include text, video, audio, and 3-dimensional models used as enhancement and instruction over real-world environments. Including these types of objects in designing learning, solutions have become the trend in instruction models, and AR offers an added dimension to incorporating these objects [40]. In this study, the development of the Basic Refinery courseware based on multimedia learning that implements the cognitive theory of multimedia learning is proven to improve visualization skills, collaborative learning experience, and employee motivation. To enhance the training module's effectiveness during the training, the researcher used an augmented reality approach that integrates current technology known as augmented reality environment through courseware to create a friendly user and flexible learning environment for the technical employees. Currently, the conventional method conducted at the training center requires the employees to attend normal training classroom. However, with the courseware usage, the employees can participate in the training program by applying the courseware as the courseware can be installed on any laptop, smart phones or tablets anywhere. Thus, this provides the flexibility to learn at their convenience with better flexibility.

7 Conclusion

The result shows that training courseware based on an augmented reality environment is useful and impactful in helping technical employees enhance their visualization skills compared to the current training module. Basic refinery courseware developed using Augmented Reality technology with enhances interactive digital mobile application provided an interactive training experience that eventually enhanced the technical employee's visualization skills and performance. The results also showed that it motivates them to learn through the courseware, making them more cooperative and developing the visualization skills more easily. This study's objective is achieved successfully to enhance the technical employees' visualization skills, increase their motivation and interests in their teaching and learning activities, and create meaningful learning. Therefore, it can be concluded that Basic Refinery training courseware based on augmented reality application is an effective and beneficial tool for training programs among the workplace's technical employees.

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