Body Language and Augmented Reality Learning Environment

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Abstract — **A recent national survey of Taiwanese students shows that their physical health condition has been worsening more than many other countries. In this study we examine use of a new learning system enhanced with augmented reality (AR) to address this growing global problem. In order to apply three different physical activities for the experiment the learners use their body language for interacting with the computer. In order to increase effectiveness of the AR system, we then combine students' academic achievement and their preferences for using the system. The experimental results from 419 students indicate much higher achievements in their academic work and gain significantly more those who come with their minds set for stronger challenging preferences in the seven subscales.**

Keywords-augmented reality; virtual reality; learning; education; preference

I. Introduction

Use of information technology (IT) in education has been known for many decades. It is well known that IT can create new learning opportunities where virtual reality (VR) has been recognized as an advance technology allowing learners to interact with both virtual and real worlds [1] at the same time bringing in potential enhancements to the process of learning [2] as well as the health activities [3]. More recently researchers have come up with better results by dividing the virtual concept into more specific groups of VR, mixed reality (MR) and augmented reality (AR) [4-5].

It is notable that AR is more technology intensive and therefore it usually comes with more contradictory views than others. Although, the initial concept of AR goes back to the 1960s, a first formal AR system by Boeing Company has been developed only in early 1990s. The most popular definition for AR is from Milgram and Kishino [6] which is: 'there is a continuum of real-to-virtual environment in which AR is a specific area within the generic area of MR'. We then have augmented virtuality (AV), also known as Virtual Reality (VR) which composes (real) objects compiled into virtual environments (VE) where the surrounding environment is therefore virtual. On the contrary, AR is surrounded by real environment. Some define AR in association with the Head-Mounted Displays (HMD) equipment. This however limits AR's capability to the sense of sight. To this effect, Azuma's [7] discusses that we should not restrict the AR by its definition to display specific technologies. He extends his view that AR should use other senses such as hearing, touch, sound, and smell [8]. Kaufmann [9] points out that VR technology immerses the user inside a complete virtual environment. In contrast, AR allows the user to see the real world and combine it with virtual objects. This enhances AR with the reality, rather than replacing it for which a user can realize that the virtual and real objects coexist at the same time.

With respect to the use of AR in learning, Chen et al [10] report that the use of AR learning system can significantly enhance children interests and motivate them in learning Chinese. Nonetheless, the use in evaluation of AR learning environment and AR user preferences is still limited [11] and requires extensive improvement. As opposed to traditional keyboard-mouse computer assisted instruction (KMCAI), in AR for any interaction with the system the learners need to use the body language. We classify these movement and gestures of the body into three types of AR physical activities of aerobic fitness, muscle strength and flexibility fitness by presenting specific meaningful postures, duration of the exercise and the degree of strength doing the exercise. In Hsiao [3] we reveal that the students using three types of AR physical activities with the AR learning system result in significantly higher academic achievements and therefore can gain a higher degree of positive attitude towards learning than those from KMCAI. In addition, the students naturally stay healthier due to being active and doing physically more exercises during their learning. By putting the learner at the centre of activities we can bring in a new factor of user approach into the process by including the 'user preferences'. We, therefore, in this study can also evaluate the user preferences in conjunction with the AR learning tools. This is easy to assess if the AR learning environment had been easier to operate. That is, if students feel that the technical part of AR learning system is challenging for them or not. Furthermore, some other essential activities of the AR learning system are examined in conjunction with the system design.

The rest of the paper is prepared as followed. The related works in the area are presented in Section 2 followed by the main idea being discussed in Section 3. In Section 4 we describe the setting up scenario for the basic experiment which is followed by some results and discussions in Section 5 before the conclusions in Section 6.

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II. RELATED WORKS

AR is developing continuously for a wide range of new applications but in here we consider its learning uses mainly for education and psychological treatment. With respect to using AR in education, as AR has the potential to engage and motivate learners to explore teaching material from the real and virtual objects, the learning environment enables learners with more interactions between the system i.e. the virtual objects and the virtual learner's image in the virtual world, the learner, and the real objects in the real world [12-13]. In terms of evaluation of AR in education, Sumadio and Rambli [11] indicate the participants show a very good feedback and enthusiasm with the AR. A similar result from an AR supported English learning system in high school has reported that the AR system not only motivates the students to learn faster but it also helps to improve their spoken English [14].

Regarding to psychological healthcare, Gorini et al [15] reveal the effects of VR in the treatment of generalized anxiety disorders. Another recent research reports an exciting result by the applications of VR for patients with Schizophrenia [16]. Concerning physical health, Schaik et al reports that participants' strongly preferred Virtual Augmented physical activity to traditional physical exercise [17]. Lamounier et al [18] proposes to investigate Augmented Reality techniques to provide new strategies to visualize and interpret cardiologic signs. This facilitates the understanding of the information by students and professionals from the Health area and even by patients.

III. OUR WORK

In this study, a new approach to the implementation of AR in the educational environment is taken by creating an AR learning system, using the current teaching curriculum, together with physical activity. This system is to combine learning with three types of physical activity: aerobic fitness, muscle strength and flexibility fitness. One of the reasons to use this AR learning system is to enhance students' learning by practicing a test in the form of a game competition. Another reason is to increase students' physical exercise if students are short of physical exercise but school has a limited time schedule [19].

A. Equipment and layout

When the AR learning system is applied in the classrooms, students need not wear a head-mounted display or other expensive equipment since more high school classrooms in Taiwan are equipped with at least one computer and a projector with a screen. Thus, we only need to use a common webcam as extra equipment for using the AR learning system. The webcam is placed in front of the students in order to capture students' gestures and body movement to interact with the AR system. Students have to wear the 'red glove' as the marker which is used to activate the sense area in the system.

Students have to do 'jumping', 'stretching' or 'boxing' in order to hit the correct answers up to some certain number of times instead of only hitting once. The webcam will capture students' gestures and body movement to interact with the system. For example, in the jumping game, students have to jump high enough in order to let their images to touch the right answer in the virtual world (Fig. 1). In order to reach some certain exercise levels, the number of times to hit the answer and jumping height could be designed by teachers.

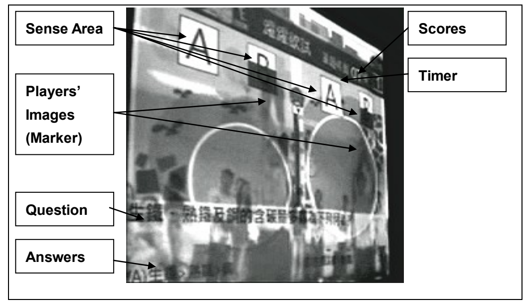

Figure 1. Example of the combination of the virtual and real objects in the AR learning system

B. The learning system

The AR learning system starts from 'Flash Animation (Test Start)' which is used to attract students' attention by some new technology novelty of audio and visual effects. After the animation, the users have to choose some certain 'Unit' from the subject content and also choose some certain 'Physical Activity' at the stage of A (Fig. 2). If students hit the correct answer by using their virtual images to touch the sense area in the virtual world up to some certain number of times by jumping or boxing, then the system will play 'Flash Animation (Correct Answer)'. In the both animations of Correct Answer and Wrong Answer, the information including the correct answer and the feedback of learning will be provided among them.

In this learning system, a player only has one minute to answer the question. For each question, there are two players from different groups to compete with each other. After the players finish the first question, another player in the same group will continue another competition on the second question. When the number of the correct answers is over 5, then the system will display 'Flash Animation (Successful Player)'. If all players in the same group finish the competition, then another two groups will replace the former two groups to start the competition. When the number of 'Successful Groups' are over 3, then the system will display 'Flash Animation (Test Pass)'. Normally, there are approximately 30 students in a class so that students are divided into 6 groups and there are 5 students in a group. In a round, two groups will compete with each other so that there are 3 successful groups at the end.

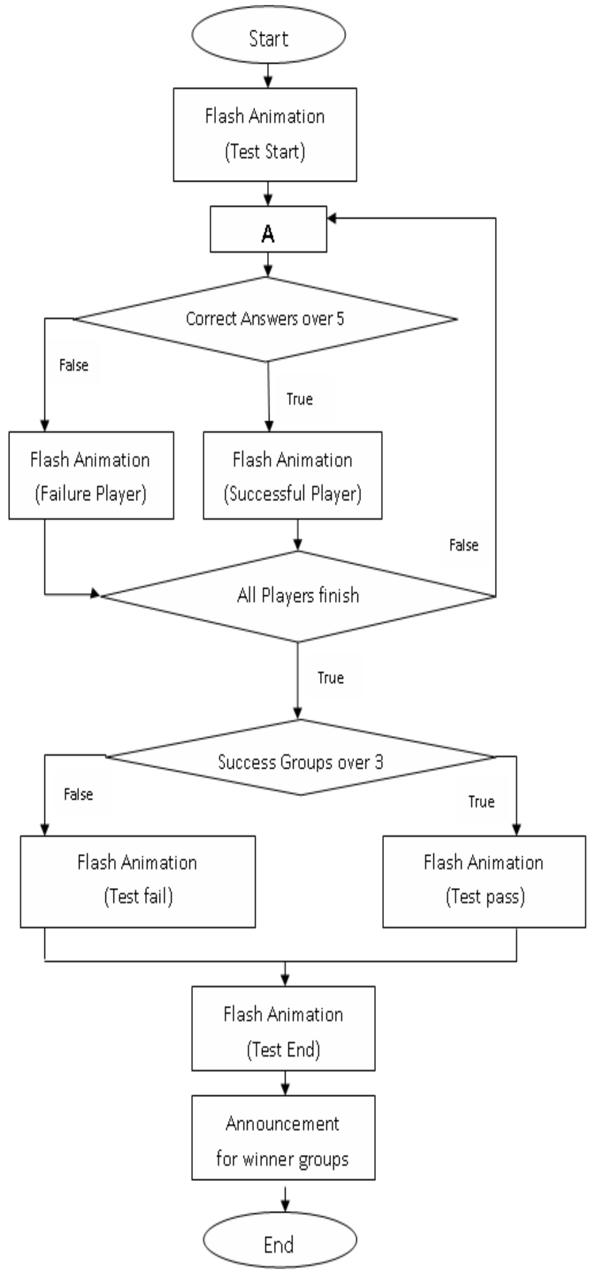

Figure 2. AR learning system

IV. TAIWAN CASE STUDY

A. Experimental chemistry teaching

In Taiwan high schools, traditional Chemistry teachers would be expected to teach students the fundamental concepts of Chemistry knowledge from the textbooks first. Following the first part of teaching activity, then they would provide 'practice' exercises to students. The 'practice' normally contains interactive communication and discussion between a teacher and the students. In this study, the AR learning system is used for students as an assisted learning tool in the second part of teaching activity, 'practice'. However, the framework of this system algorithm is not specifically designed for the Chemistry and Science curriculum but applicable to any subjects and learning systems.

B. Participants

The participants in this study were 419 high school students from 5 high schools located in the North of Taiwan. Students are all involved in the AR learning system but use different types of AR physical activity. Thus, based on the type of AR physical activity, they were divided into three groups: Group AR-Jump used aerobic fitness, Group AR-Stretch used flexibility fitness and Group AR-Box used muscle strength.

C. Instruments

Several evaluation techniques were applied including observations, questionnaires, paper-&-pencil tests and interviews. In order to explore students' preferences towards the use of the AR learning system, a questionnaire was developed for the users' preferences to classify the preferences of learners engaged in the augmented reality learning environment. Further, in order to examine students' progress on academic achievement within the use of AR learning system, pre-test and post-test paper-&-pencil examinations were applied in this study. Both the questionnaires and pre-test and post-test paper-&-pencil examinations were commented on and the items for content validity by four subject teachers from four high schools and one director of Teaching Affairs.

1) Questionnaire Design: A questionnaire was developed for the user preferences of the AR learning system to classify students' preferences toward the augmented reality learning environment. The questionnaire was integrated from the Constructivist Multimedia Learning Environment Survey conducted by Maor [20] and the Preferences for Internet Learning Environment Survey developed by Tsai [21] but modified based on the features of the AR learning environment and finally classified the questionnaire into seven subscales: 'Ease of Use (EU)', 'Challenge (CH)', 'Rewards (RW)', 'Situated Learning (SL)', 'Collaboration (CO)', 'Competition (CP)' and 'Movement (MO)'.The questionnaire consists of seven subscales which were used to assess students' preferences with the use of the AR learning environment. 'Ease of Use' was applied to assess if students feel the AR learning environment was easy for them to use in the technical aspect. 'Challenge' was used to assess if students feel the content in the AR learning system was challenging enough for them. 'Rewards', 'Collaboration', and 'Competition' were to explore the effects of the learning activity within the use of the AR learning system on to students' learning process. Finally, 'Situated Learning' and 'Movement' were used to assess the impacts of the 'Situated Learning' and 'Movement' design in the AR learning system on students' learning. The items in all seven subscales of the preference questionnaire are scored on a five-point Likert scale ("strongly disagree," "disagree," "normal," "agree," "strongly agree"). While for the "strongly agree" responses was assigned a score of 5, for the "strongly disagree" responses was assigned a score of 1. Therefore, when students obtained higher scores in the scales, it represented that they showed stronger preference towards this feature. The reliability coefficients (Cronbach's alpha) for these seven subscales are 0.929, 0.927, 0.919, 0.943, 0.945, 0.945 and 0.955, respectively. The total reliability coefficient for the preference questionnaire is 0.985.

2) Pre-test and post-test academic achievement: In terms of academic achievement, pre-test and post-test, paper-&-pencil examinations were applied in this study. Eight items of the memorised type and seven items of the non-memorised type were included in these two tests. However, only eight items were the same in both of the pre-test and post-test and the other seven items were different but of the same level of difficulty which was identified by four subject teacher from four high schools and one director of Teaching Affairs.

V. RESULTS AND DISCUSSION

In this study, a series of statistical test analyses were conducted to examine three types of students' academic achievement. In order to examine the effect of the different teaching approaches on academic achievement, a dependent (repeated measure) t-test was applied. All students' academic achievement in three AR groups was tested at the beginning of (pre-test) and at the end of (post-test) learning the same unit in high school Science by the paper-and-pencil methods. Students' pre-test and post-test were treated as matched variables. Table I revealed that all students' academic achievement in three AR groups progresses significantly after the use of the AR learning system. It indicated that the AR learning system did have a positive effect on their academic achievement progress for all three AR groups.

TABLE I. A DEPENDENT (REPEATED MEASURES) T-TEST VALUE FOR THE STUDENTS' ACADEMIC ACHIEVEMENT IN THREE AR GROUPS

	Mean Difference	SD	t	df	p
R-Jump	0.640	2.638	2.862**	138	0.005
AR-Stretch	1.014	2.594	4.643***	140	0.000
AR-Box	0.518	2.852	2.141*	138	0.034

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.005$

In the analysis of the differences in three types of students' academic achievement, the dependent variable is post-test and pre-test is set as the covariate. On average, the means of academic achievement in AR-Jump, AR-Stretch, and AR-Box were 7.208 (SE=0.207), 7.603 (SE=0.205), and 7.145 (SE=0.207), respectively. However, regardless of the types of physical activity, there is no significant difference among all three AR groups of academic achievement. It revealed that the AR learning system did have the positive effect on their academic achievement progress regardless the types of AR physical activity they engaged in.

In term of students' preferences toward the AR learning environment for the three AR groups, on average, students showed stronger preferences towards the AR learning environments (an average score of 3.71 in Group AR-Jump, of 3.57 in Group AR-Stretch, and of 3.65 in Group AR-Box, respectively, in the 1-5 Likert scales). Table II shows the correlations between students' academic achievement and their responses on the preferences towards the AR learning environments. The results indicated that, in the Group AR-Box, students' TAA was positively and significantly correlated with two preference subscales: the Ease of Use (EU) subscale and the Challenge (CH) subscale ($p < 0.05$ and $P < 0.005$ respectively). In other words, students obtaining higher academic achievement scores tended to prefer AR learning environments where they could operate the AR learning system easily in the technical aspect and they feel the content if the AR learning was challenging enough for them. For the other two types of AR groups, there is no significant result between students' academic achievement and their preference response on AR learning environments.

TABLE II. CORRELATIONS BETWEEN STUDENTS' ACADEMIC ACHIEVEMENT AND PREFERENCES

	EU	CH	RW	SL	CO	CP	MO
AR-Jump	0.114	0.049	-0.060	-0.038	-0.060	-0.038	-0.069
AR-Stretch	0.066	0.181	-0.106	-0.037	0.035	0.138	0.135
AR-Box	0.235*	0.289**	0.081	0.199	0.165	0.137	0.112

* $p < 0.05$, ** $p < 0.01$

VI. CONCLUSIONS AND FUTURE WORKS

This study has developed an augmented reality learning system with effective functions of three types of physical activity as well as plentiful learning material to help high school Science learning. An evaluation on academic achievement and students' preferences toward the AR learning environment was implemented. There are some exciting results found in this study.

Firstly, the results indicated that students, in all three types of physical activity within the use of the AR learning system, have significantly positive progress in their academic achievement between the beginning and the end of their studies.

Secondly, regardless to the types of AR physical activity students engaged in, they all obtained the equally positive effect on their academic achievement progress.

Finally, in terms of students' preferences toward the AR learning environment for the three AR groups, students showed stronger preferences (all means > 3) towards the AR learning environments including all seven subscales, Ease of Use, Challenge, Rewards, Situated Learning, Collaboration, Competition and Movement. This study also found that students engaged in the AR Boxing physical activity and obtaining higher academic achievement significantly tended to be in favor of the easy use and of the challenging content in AR learning environment. Further, it is also revealed that students' preference toward the challenging content in the system and their academic achievement significantly had the strongest positive correlation (Fig. 3).

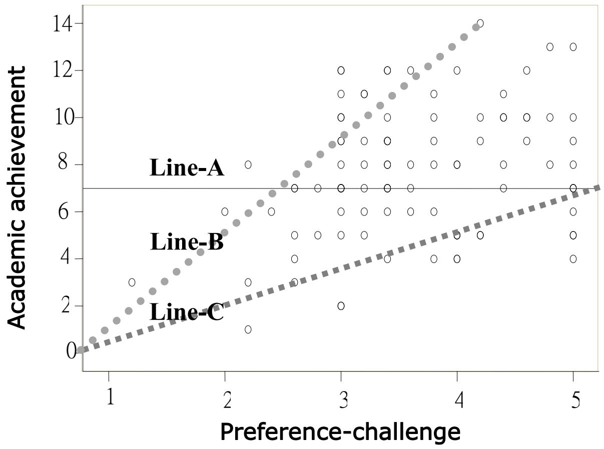

Figure 3. Positive correlation between academic achievement and Challenge in Group AR-Boxing

In Fig. 3, the reference Line A is the mean of students' academic achievement in Group AR-Boxing. The plot shows that most data converge on the area between reference Line B and Line C with very few discrete data. Academic achievement and preference-challenge in Group AR-Boxing has linear positive correlation.

The results of the preference evaluation on the AR learning environment provided a promising way to adjust our current AR learning system in the future and also a useful reference for those whom are going to develop their own AR learning system.

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