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A Scenario-triggered Learning Environment with Augmented Reality for Situated Learning

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Abstract: In this paper, we propose AR-assisted digital learning playground that a teacher and students can stand around and complete tasks with a robot partner in the classroom. We applied Augmented Reality technology to conventional flashcards. AR cards serve as task toolkits that students use cards to trigger apt scenarios in the task. We assume that students can acquire knowledge by interacting with the apt scenarios shown on the screen. The result of the experiment depicts that this reflection-in-action learning mechanic yield relevant learning experience.

Keywords: Task-based learning, augmented reality, Digital Learning Playground

1. Introduction

Acquiring applied capabilities in schools has been called into question from concerned community members. School learning is commonly thought to include a lot of cognition and abstract concepts and lack connections to the actual contexts of objects and events [3]. Skehan (1998) states that knowledge must be applicable and related to the real world [6]. For this reason, many scholars have advocated using experiential learning and task-based learning which involves situational task design, as the method for students to apply knowledge, thereby gain actual experience. That is to say, “relevant contexts” and “actual experience” are essential to learning. In this study, we are searching for a solution that students can learn with context-relevant materials and meanwhile have opportunities to apply knowledge in classrooms.

2. Motivation and Related Work

2.1 Task-based Learning and Knowledge-in-use Experience

Knowledge-in-use is a combination of declarative, conceptual or procedural knowledge that is necessary to perform a given task, solve a problem or handle a complex situation [6]. In terms that school-base learning contains a lot of abstract concepts and rote memorization, putting tasks into pedagogical design makes knowledge more explicit and relevant to learners. Ellis (2003) describes that a task provides a context for learners to engage and work as language users [2]. It can be summarized that the essence of task-based learning is to apply knowledge within a designed context regarding target learning. The application of Augmented Reality (AR) on educational innovation has become an applicable tool in the field of Geometry, Geography, and language learning. Wojciechowski et al., (2004) proposed a system with VR and AR presentations, which made museum exhibitions more interactive to museum visitors [8]. Hsieh and Lee applied AR to upgrade the traditional English teaching flashcards into 3D flashcards. Users can move around the 3D cards and observe 3D displays in any directions [4].

AR can provide good presentations on dimensional objects and images. However, there were few AR applications that were embedded in task-based teaching and learning. We see the potential of cooperating AR to task-based learning. We are trying to build a task-given or situated learning environment that learners can use AR-knowledge-kit to interact with the given situations and gain actual knowledge-applied experience.

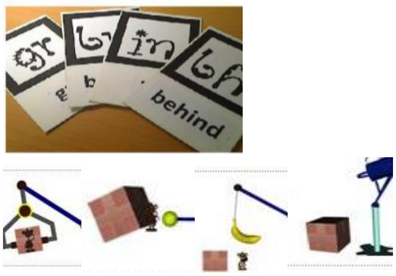
3. System Design

3.1 Digital Learning Playground with a Robot Partner

When students learn a particular set of knowledge, the course designer should create opportunity for students to apply the learned knowledge in the assigned tasks. Students will perform their tasks and encounter different scenarios. We built designed scenarios into Digital Learning Playground (DLP) [1], an L-shape equipment that consists of a tabletop and a screen: the screen can present various animated scenarios; and the table provides a platform for play-together and task performance. Thus, students perform tasks, and acquire knowledge in the process of task completion. DLP forms a learning space that teachers and students can stand around and get hands-on experience in the classroom (Figure 2). Moreover, we also applied a robot as a learning partner to help students complete their learning tasks on the stage. Using robots on the stage enables students to observe the entire learning surroundings and task completion process.

3.2 AR-assisted Environment and AR Cards

In order to enhance task-based learning environment, we design an Augmented Reality (AR) setting without head-mounted displays. We add AR component to conventional flashcards. We not only use cards as knowledge presentations but also a set of tasked kits. When performing tasks, students pick up their decided AR cards to trigger the associated scenarios (Figure 1). This task mechanic, text on cards- enhancing cognition, and associated scenarios- embedding associate contexts, provides a relevant comprehension and knowledge-applied experience. The robot partner has also been tagged with AR tags that students can see a virtual avatar to interact with the setting on the screen (Figure2).



in behind beside under

Figure 1. AR cards and toolkits shown on the screen

Figure 2. Digital Learning Playground

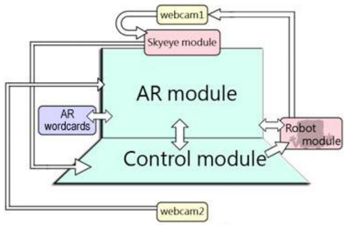


Figure 3. System Architecture

4. System Implementation

4.1 Digital Learning Playground supported with Augmented Reality Technology

The hardware setup of DLP includes a PC, a tabletop with a vertical screen, two projections and two webcams, and a robot (Figure 3). The PC (Control module) is the computational component for the system operation. Two projections, one set on the top of the screen and the other set in front of the table, projecting the presentations of the ground scenery and the screen displays. The tabletop is the stage where the robot can perform and students can stand around. The robot (LEGO ® MINDSTORMS ® NXT 2.0) is connected to the PC via Bluetooth so that it can be remotely controlled or perform auto-walk. The robot's head is equipped with an IR emitter (Robot module), which sends its position information to webcam1, and then to the PC. Along with this positioning system (Skyeye module), a teacher can control the robot's position by a Bluetooth wireless keyboard. Also, we use an open source, ARToolKit-2.72.1. It helped us to build AR applications. The AR cards printed with the texts and a black-square AR tags. Webcam2 (AR module) captures AR tags and processed 3D images and animations to the screen.

4.2 Instructional Design

Learning materials were picked from *New Go SuperKids*, Pearson, Longman. The language learning topics are colors (pink, purple, gray, brown) and locations (in, behind, beside, under). The learning goals are: learners will be able to recognize vocabulary of "Colors" and "Prepositions."(cognitive knowledge); identify colored objects and locations (declarative knowledge); give directions and answer questions about locations, such as *Where's _____? It's ___ the ____.* (procedural knowledge). The designed task is Hide-and-Seek, a childhood game, embedded as a situational context. The teacher delivered a lead-in story that included the learning content and task instruction. To continue the storyline, the students were divided into two teams, "Hiding Monkeys" and "Seeking Monkeys." Each team had their missions: Hiding Team (HT) to hide eight monkeys in four colored boxes with four prepositions; and Seeking Team (ST) to seek all the monkeys which were assigned in different boxes previously from HT. The robot guided tasked-required action by initiating questions and then, ST showed the colored card and told the robot to the assigned box. Once the robot got to the box, ST showed their decided "preposition" card in front of the screen. The image of the card on the screen became designed tools to attract the hiding monkeys out of the box. The class would see series scenarios during the process. Taking turns experiencing hiding and seeking process is regarded as a whole set of task learning.

5. Experiment and Result

This research is to investigate that the learning environment- an AR-assisted Digital Learning Playground for situated learning can achieve learning effectiveness- acquiring knowledge comprehension and knowledge applied capability. We propose the hypotheses as following:

1. Utilizing knowledge in tasks can enhance learning effectiveness.
2. AR-assisted learning-aids, the flashcards triggering scenarios, can create an immersive, interactive, and comprehensible learning environment.

5.1 Procedure

The experiment site is in Xindian Elementary School, New Taipei City, Taiwan. The participants were 30 elementary school second graders, whose English was their foreign language. All the subjects went through a pretest and post-test before and after using the system. The subjects were randomly divided into an experimental group (E) and a control group (C). The experimental group learned cooperatively by using AR cards in tasks at DLP; the control group learned with the same learning content, and settings- an instructor and the media (DLP), but with the difference of learning without applying knowledge in tasks (non-using-AR cards). The learning set-up for the C group is to minimize the experiential varies but close to ordinary teaching and learning. The main learning process included: a lead-in story and instruction and tasked performance on DLP. The main activity lasted 40 minutes. Afterwards, a post-test and a questionnaire were conducted to evaluate learning effectiveness and experience in use of the system. The post-test included a paper-based standard test (achievement test) for words recognition and one-by-one oral test (speaking meanings based on the contextual clues) as a performance test. Besides that, we also videotaped the whole learning process to gain the observational data.

5.2 Results Analyses

Our resulted data included users' assessment and evaluation of learning experience. The assessments are: a pretest, an achievement test (post-test I) and a performance test (post-test II). The objective of the pretest was to determine each student's prior knowledge; the post-test II and I assessed how much the learners have learned through the system.

5.2.1 Assessment Results

The results were showed on Table1. As to the subject's prior knowledge (pretest), we did a two-tailed t-test (p = 0.979, p> 0.05) and found no significant difference, indicating that prior knowledge and literacy level among the subjects were about the same. With regard to post-test I, the two-tailed t-test (p = 0.046, p <0.05) of the achievement test between two groups had a significant difference. This is to say that learning achievement in the E group was higher than the C group. With relation to the performance test, the result (p = 0.462, p> 0.05) found no significant difference. The results of speaking performance in both groups were not higher than we expected. Referring the result to the observational data and students' context, we inferred that their practice through the task might be too short, which was not long enough for the second graders to reach proficiency in speaking.

Test	Groups	N	Mean	Std. Dev.	Two-tail t-test			
					F	t	df	Sig.(p)
pre-test-cognitive	Experimental	15	74.61	22.56	1.702	0.026	28	**0.979**
	Control	15	74.43	15.64				
post-test I Achievement	Experimental	15	88.67	13.56	0.541	2.090	28	**0.046**
	Control	15	77.75	15.02				
post-test II Performance	Experimental	15	53.08	32.36	1.950	0.745	28	**0.462**
	Control	15	45.18	25.27				

Table 1. T-test of pre-test and post-test with control and experimental group

5.2.2 Questionnaire

The questionnaire was administered about users' perception of learning experience. We adapted the evaluation framework for Immersive Virtual Environment by Roussos et al. , but replaced VR-assisted environment to AR-assisted [7]. The evaluated factors are: orientation, collaborative AR, and pedagogical aspects. Referring to this research's hypothesis 2, the aspects intend to determine whether DLP can create immersive, interactive, and comprehensible learning environment. The questions were quantified using a five-point Likert scale (5 points being strongly agree; 1 point being completely disagree). The actual questionnaire was converted into spoken words, which were expressed verbally due to our students' literacy level.

Orientation aspect was to exam the user's perception to the learning setting regarding to immersion and engaging in tasks. According to the figures in Table 2, the data of 93.8% and 88.9% of the E and C group (agreed and strongly agreed) indicated that the extent of immersion is high enough to both groups; Collaborative AR aspect is measured the added value of collaborative AR to instruction and learning. 93.8% of the E group strongly perceived the feedback from the system while used AR cards; 33.3% of the C group paid attention to the feedback from the system (scenarios). In other words, the result proved that AR application could create an interactive learning setting. As to the benefits of pedagogical use, like peers collaboration, and turn taking, around 80% to 90% of each group expressed that they have discussed strategies with their fellows and took turns doing the performance.

	Orientation aspect (2 questions)						Collaborative AR aspect (2 questions)						Pedagogical aspect (2 questions)					
	Degree(%)						Degree(%)						Degree(%)					
G	N	CD	D	UN	A	SA	N	CD	D	UN	A	SA	N	CD	D	UN	A	SA
E	15	11.1	0	0	11.1	77.8	15	22.2	0	0	11.1	66.7	15	11.1	0	0	22.2	66.7
C	15	0	0	6.3	6.3	87.5	15	6.3	6.3	0	0	87.5	15	6.3	0	0	0	93.8
E	15	22.2	0	0	33.3	44.4	15	44.4	22.2	0	11.1	22.2	15	33.3	0	0	0	66.7
C	15	6.3	0	6.3	6.3	81.3	15	0	0	6.3	0	93.8	15	6.3	6.3	0	6.3	81.3

Table 2. The results of the Orientation, Collaborative AR, and Pedagogical aspects from the questionnaire

6. Conclusion and Discussion

The summarized results of the questionnaire explained that the addition of AR cards to the learning task had a positive influence in learning. Converting the content of learning into hands-on tasks can enhance learning effectiveness.

6.1 Experimental Observation Discovery

During the activity, the subjects were eager to use AR cards and practice the target knowledge to achieve the task. For instance, when the robot was heading to a wrong direction, some students tried to guide the robot in a right direction by telling and showing cards. At the last experimental day, we had an informal interview to the subjects. We asked about the apt animation regarding to each flashcard (target learning). We found that most students were able to recall the scenarios and connect the scenarios to the associated cards. This shows that the students derived meaning through context clues. The scenario-triggered tasked learning can enhance learners' comprehension and a deep impression among the students.

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