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Digital Learning Playground: supporting authentic learning experiences in the classroom

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This study proposes a platform to provide a near-authentic environment, context, and situation for task-based learning. The platform includes two projection screens (a vertical and a horizontal screen) combined for situated or authentic learning. The horizontal screen extends the vertical screen scene to form a space for learning activities and performance. The platform creates learning situations using robots as surrogates of students to accomplish real-life tasks. Kolb's four-stage experiential learning cyclical model was adopted in the learning design. A simple practice was developed to examine the effect on teaching children English as a foreign language. The results reveal that children could engage deeply and feel more enjoyment using the system. Moreover, as surrogates for students to imagine that they are accomplishing real-life missions, robots could be a vital element of authentic learning in future classrooms.

Keywords: improving classroom teaching; interactive learning environments; architectures for educational technology system; teaching/learning strategies

Introduction

Teachers are occasionally the main learning resources of students obtaining knowledge, mainly by listening to lectures. Consequently, students often lack opportunities to apply what they have learned in real life causing them to neglect underlying principles and interrelated concepts. Conversely, engaging learners in authentic learning activities and discussing what they have learned could lead to greater retention of knowledge and higher recall rates (Dale, 1969).

Learning can be meaningful when applied in an authentic context (Gagne, Wager, Golas, & Keller, 2004). How can a traditional classroom realize the benefits of real-world situated learning? Authentic learning activities often consist of environments that can be created in both digital and physical settings, by creating

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characters for various roles (Van Vugt, Konijn, Hoorn, Keur, & Eliens, 2007). The authentic learning experience can also be categorized into 10 design elements: real-world relevance, ill-defined problems, sustained investigation, multiple perspectives, collaboration, reflection, interdisciplinary perspectives, integrated assessment, polished products, and multiple interpretations (Lombardi, 2007). For instance, Ranalli (2008) used a simulation game (i.e. The Sims) with additional materials as an authentic activity for students to play while learning English as a second language. Wong and Looi (2010) used mobile devices to create an authentic context for learning vocabulary. Accordingly, the major basis of this article is derived from both authentic learning and learning-by-doing theories (Herrington & Oliver, 2000; Schank, Berman, & Macpherson, 1999).

We designed a learning platform called the "Digital Learning Playground" (DLP) to create a near-authentic learning environment in the classroom. A robot with emotional feedback was designed to perform the role of a learning agent. Kolb's (1984) four-stage experiential learning cyclical model was adopted in the instructional design. Kolb's experiential learning theory was chosen because it provides a learning framework and holistic process to design interactive learning experiences (Bolan, 2003).

Kolb's approach consists of three parts: experiential learning theory, a learning cycle graphical model, and a learning styles inventory (Kolb, Boyatzis, & Mainemelis, 2001). Figure 1 shows the transforming processes combining Kolb's (1984) four-stage experiential learning cyclical model. Students learn abstract concepts and test them by experimentation in a conventional classroom setting. Currently, the activities for concrete experience and reflective observation stages are seldom implemented in conventional classrooms because of the lack of an authentic context; that is, a sustained and complex environment for learners to explore at length. The DLP adds concrete experience and observation to fulfill the experiential learning cyclical model. The middle of Figure 1 shows that the educational robots and mixed reality (MR) were integrated to construct an authentic context. Moreover, three instructional methods, including knowledge orientation, knowledge application, and knowledge observation, were also designed for teachers and students to conduct authentic learning activities after constructing the DLP.

This study identified the critical characteristics of simulated authentic learning to design the DLP and transform conventional classrooms. Two major mismatches in authentic and academic learning, approaches to knowing vs. approaches to understanding, are listed in the first column of Table 1. The first mismatch (i.e. approaches

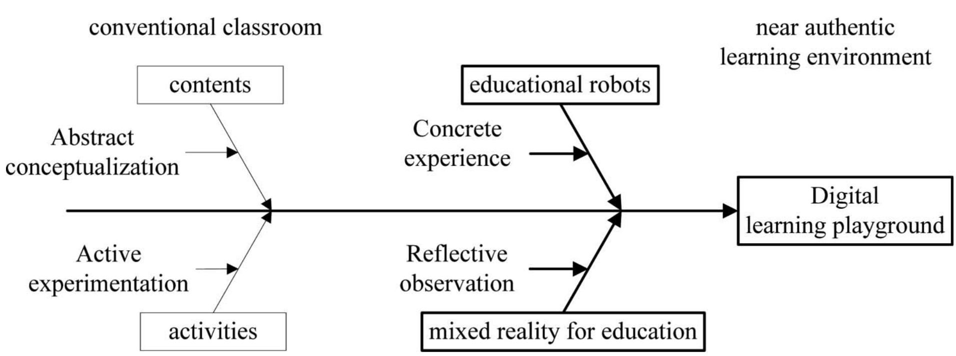

Figure 1. Process of transforming the classroom into a near-authentic learning environment.

Table 1. Transform experiential learning by the Digital Learning Playground.

Mismatch between authentic and academic learning	Transformed by Digital Learning Playground	Transform to simulated authentic learning activity
Approaches to knowing	Educational robots	Concrete experience
Apprehension vs. comprehension	Conventional materials	Abstract conceptualization
Approaches to understanding	Mixed reality for education	Reflective observation
Connotation vs. denotation	Conventional activities	Active experimentation

to knowing) is derived from how a learner acquires knowledge by direct practical experiences or comprehensive theories (''apprehension vs. comprehension'', in Kolb's terms). For instance, learners apprehend that they cannot touch fire after doing so and burning their fingers. However, comprehension does not require concrete experience to understand. The second mismatch (i.e. approaches to understanding) is derived from what experiences in the real world mean to learners. For instance, understanding the concept of planets denotes specific objects, such as Venus, Earth, Jupiter, and Neptune. Therefore, learners can understand definitions of a concept during the active experimentation stage. In contrast to denotation, learners understand a concept from shared attributes of all objects, such as atmosphere and temperature of a planet, by the mode of connotation. In the active experimentation stage, learners extend their knowledge to obtain denotation by testing in the real world. However, the skill of reflective observation (i.e. connotation) from concrete experience is more important from the perspective of preparing students for the future.

The second column of Table 1 lists materials and activities used to transform a conventional classroom into the DLP. Educational robots create concrete experiences for learners, and MR creates an authentic context to stimulate learners' reflective observation.

Environmental setting in the DLP

The concept of a responsive stage is derived from the setting of a dramatic stage. To simulate a dramatic stage in the classroom, the researchers in this study used two projection screens (a vertical and a horizontal screen) to set the responsive stage. The vertical screen presents the learning situation scene and feedback during learning activities. The horizontal screen extends the vertical screen scene to form a space for learning activities and performance, provides a space for the robot to navigate (as shown in Figure 2), and allows five or six users to complete the learning task simultaneously. Teachers can use the vertical screen to explain learning content and demonstrate system operational procedures.

The equipment of a DLP includes a computer, two projectors, a portable projector screen, a table, and a robot. The total cost of the equipment for a DLP is approximately US$3000.

Learning activities

This study adopted Kolb's experiential learning model as the core system rationale for designing learning activities. Experiential learning highlights learners' direct

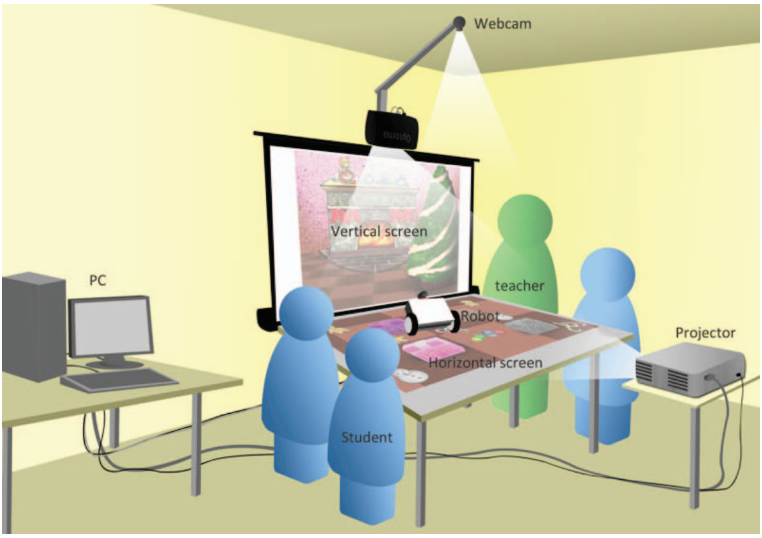

Figure 2. Environmental setting of the Digital Learning Playground.

experiences and reflections on learning. Developing the learning process was based on the four-stage learning cycle proposed by Kolb. The current study adopted this concept to design learning activities as an "act–respond–reflect" learning cycle, according to the experiencing stage and reflecting stage of experiential learning. Each learning activity in the system included the following: (1) act – using knowledge to control material in the system, the researchers in this study turned learning content into robot commands and allowed the students to use the content to interact with the robot and stage; (2) respond – immediately displaying the results of student operations, the system presented the immediate results through multimedia based on the interaction between the students and the system; and (3) reflect – the students knew whether they used knowledge appropriately through the system of feedback. Based on this feedback, the students could introspect whether they used knowledge (learning content) effectively as the foundation for follow-up learning interactions.

Research design

This study examined the impacts of implementing the DLP on student behaviors and perspectives on learning. In addition, a questionnaire survey was administered to collect data, and the pretest–posttest design was adopted to evaluate the effects of the learning environment on students.

Learning context

This study chose "spatial prepositions" and "color" as objectives for participants at the elementary level. For "spatial prepositions," students should learn "on," "in," "beside," and "behind." For "color," students should learn "brown," "gray," "purple," and "pink." For learners' ages, the researchers in this study used a "hide-and-seek" game familiar to elementary students as the learning activity topic. The learning activity design included eight monkeys and four gift boxes individually colored pink, purple, brown, and gray (Figure 3). The monkeys always like to hide in the gift boxes. The monkeys can hide in three places: inside, beside, and behind. The robot (Figure 4), who is made to resemble SpongeBob™, the character from the American animated television series, is a zoo keeper and worries that he might not know where the monkeys are hiding. Therefore, Sponge Bob requires the help of students to find them. According to the activity design, students are divided into two groups for the hide-and-seek activity: hiding the monkeys and finding the monkeys.

At the beginning of the learning activity, the teacher first demonstrates how to operate the system and teaches the English lessons of "spatial prepositions" and "colors" to the students. Students must apply the learned knowledge to interact with the system in the learning environment to accomplish the learning tasks. The learners must use the learned knowledge to complete the tasks ("act"). For example, when the students want the robot to proceed to the pink box, they must say the word "pink" to

Figure 3. Learning context scene.

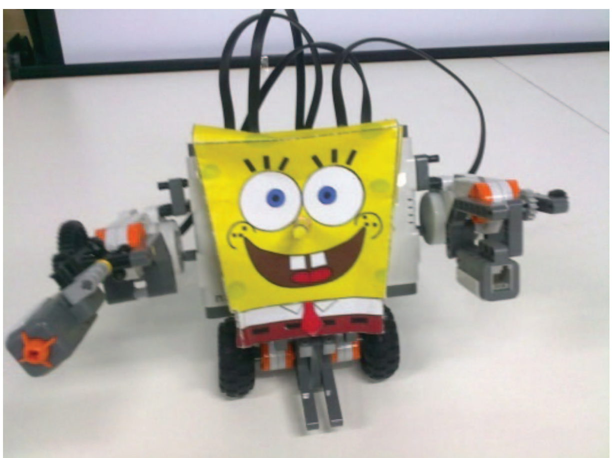

Figure 4. Sponge Bob.

prompt the robot move forward. The responsive stage displays the results and provides feedback based on learner behaviors and knowledge (“respond”). For example, when a student says “behind,” the responsive stage shows the animation of a monkey emerging from behind a box if it was hiding behind the box. Conversely, if no monkey was hiding behind the box, the responsive stage shows an image with incorrect answers. In the experimental activity, students obtain problem-solving experiences by connecting previous experiences and problem introspection (“reflect”). For example, when students know the answer is incorrect after viewing the image in the scene, they reflect on the previous experience and try again until they obtain the correct answer.

Students use a target language in the learning activities and gain feedback from the system. The feedback includes three parts: act, respond, and reflect. (1) Feedback of act: Learners must use learned knowledge to complete the tasks. For example, when students want the robot to proceed to the pink box, they must say the word “pink” to prompt the robot move forward. (2) Feedback of response: The responsive stage displays the results and provides feedback based on learners’ behaviors and knowledge. For example, when students say “behind,” the responsive stage shows the animation of a monkey emerging from behind a box if it was hiding there. Conversely, if no monkey was behind the box, the responsive stage shows the image with incorrect answers. (3) Feedback of reflect: Students obtain problem-solving experiences by connecting previous experiences and problem introspection in the experimental activity. For example, when students know the answer is incorrect from the image in the scene, they reflect on the previous experiences and try again until they obtain the correct answer.

Procedures

Sixty Taiwanese sixth graders from an English learning cram school participated in this study. Each participant took a pretest and posttest before and after the learning activity. Participants had 10 min to answer eight questions in the pretest and posttest. These questions comprised two parts: (1) connect the colors drawn in concrete figures and the colors written in text; and (2) examine pictures and indicate the spatial prepositions for a ball and a box. After completing the pretest, participants were randomly assigned to either an experimental or a control group. Each group totaled 30 students, and the length of a learning session for each group was 50 min. The English teacher used the lecture method to teach the control group (as shown in Figure 5 on the left). The story, *A Color of His Own*, paper dolls, and

Figure 5. Learning activities of the control and experimental groups.

flash cards were used to teach the topic. The teacher interacted with the students throughout the learning activity and allowed the students to operate the paper dolls at different positions and answer questions.

The experimental group used the DLP to play the hide-and-seek activity. The teacher spent 10 min teaching the lesson at the beginning of the learning activity. The students were then divided into two groups: one group hiding the monkeys and the other group finding them. The finding group was directed into another room until the other group had finished hiding the monkeys. The finding group was then directed back to the classroom and had 7 min to find the monkeys while the other group watched. At the end of the activity, the groups switched roles to play the game again. All actions in the activities were conducted using voice commands, including hiding the monkeys and moving the robot. At the end of the lesson, each student was administered a test and a questionnaire. Some of the students were asked to provide simple feedback of their experiences.

Results

The questionnaire is specifically designed to gather feedback from participants. The questionnaire includes three parts: (1) participants' feelings of MR interaction and learning; (2) participants' feelings of their learning processes; and (3) participants' perceptions of the robot's emotional responses. These results were used to determine the students' feelings and learning progress, as well as how to improve the system. The questionnaire used in this study involved a five-point Likert scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), to obtain raw scores from students. The mean and standard deviation of each question were quantified according to student answers for data analysis. The researchers in this study also calculated the percentage of agreement population (score $\geq$ 4) for each question. The effects of student learning achievement from this experiment were evaluated by comparing the test grades of the two groups.

Learning experience in the DLP

Referring to the authentic assessment factors proposed by Gulikers, Bastiaens, & Kirschner (2006), the questionnaire was developed to examine the learning experience in the DLP. The learning experience included the sense of authenticity, engagement, and learning motivation. Table 2 shows the questions and analysis results. According to the results of the first two questions, 80% of the students agreed that a timely response of the system can create learning pleasure (mean = 4.37), and 90% of the students thought that the learning process is similar to real-life experience (mean = 4.50). This result means that the students believed the system to be authentic. The results of Question 3 (mean = 4.70, 100.0%) indicate that most of the students engaged more in the learning activity when the robot displayed negative emotions. Additionally, 93.3% of the students indicated that Sponge Bob (the robot) inspired them to increase their focus on the activity (mean = 4.67). This also means that the robot's interaction with emotional feedback had a positive effect on student learning motivation and concentration. In addition, 83.3% of the students indicated that the class was more interesting when using the system (mean = 4.47), and 90% of the students felt pleasant during the learning process (mean = 4.63). The results demonstrate that the users were highly engaged in the task constructed in an authentic learning environment.

Instructional effects and learning impact in the DLP

The second part of the questionnaire evaluated the instructional effects of the DLP. Table 3 shows the questions and analysis results. The result of Question 1

Table 2. Learning experience in the Digital Learning Playground.

Statement	Mean	SD	Score ≥ 4 (%)
Authenticity			
1. When using the interactive learning system, I could see the monkey hiding in the box on the screen when I gave the command "in." This type of interaction makes learning fun and interesting.	4.37	0.89	80.00
2. When using the interactive learning system, I feel like I am playing "hide and seek" with the monkeys in real life.	4.5	0.900	90.00
Motivation			
3. When the robot indicates that it is unhappy or tired, I work harder (e.g. say the terms louder) to normalize the robot's condition.	4.70	0.466	100
4. When using the interactive learning system, I focus on the activity.	4.67	0.606	93.30
Engagement			
5. Using this system to learn English is more interesting than the traditional method.	4.47	1.008	83.30
6. I feel happy when using the interactive learning system.	4.63	0.765	90.00

Table 3. Instructional effects and learning impact in the Digital Learning Playground.

Statement	Mean	SD	Score ≥ 4 (%)
1. When using the interactive learning system, I had to use the "in," "beside," and "behind" commands to complete the task of hiding and finding the monkeys.	4.87	0.346	100
2. When using the interactive learning system, I could see the monkeys hiding in the box on the screen when I gave the "in" command.	4.87	0.346	100
3. Within the interactive learning system, when I used the command "in" to find the monkey, I could see the monkey jumping out of the box on the screen. This way helps me know the meaning of the word "in."	4.63	0.556	96.70
4. I learned the words "in," "behind," and "beside" from this activity, so I can describe the location of a ball, for example.	4.77	0.568	93.30
5. When using the interactive learning system, I felt like I was playing "hide and seek" with the monkeys and was not being forced to learn English.	4.6	0.675	90.00
6. Using the interactive learning system to learn English is more effective.	4.63	0.615	93.30

(mean = 4.87, 100%) shows that all of the students had to use learning content to complete learning tasks in the learning process. In Question 2, all of the students indicated that a timely response from the system was necessary (mean = 4.87, 100%). For the third question, 96.7% of the students indicated that they were able to understand knowledge and learning content by observing the correct response from the system (mean = 4.63, 96.7%). According to the results of the three questions, most of the students obtained the "act–respond–reflect" learning experience.

According to the results of Question 4 (mean = 4.77), 93.3% of the students thought that they could transfer the knowledge they learned to similar situations. The results of Question 5 (mean = 4.60) show that 90.0% of the students felt that in the learning process, they played a hide-and-seek game with monkeys instead of being in English class. This result shows that the students felt involved in a real situation, and thought that the system provided an environment where they experienced a real situation. The results of Question 6 (mean = 4.63) indicate that 93.3% of the students thought that this learning system resulted in a greater learning achievement.

Learning effectiveness

We attempted to understand the effects of the learning environment based on the students' learning achievement. Table 4 shows the results of the pretest and posttest of the two groups. Prior to the experiment, the researchers in this study investigated whether a difference in previous knowledge existed between the two groups based on their pretest scores. We found similarities in the mean scores of the two groups and no significant difference between the independent *t*-test results ($p = 0.675 > 0.05$) of the two groups. Therefore, previous knowledge of both groups was similar.

Following the experiment, an analysis of the posttest scores was conducted. The mean score of the experimental group was nearly 81 and the mean score of the control group was 68. We found a significant difference in student scores between the two groups, based on the independent *t*-test results ($p = 0.028 < 0.05$). The experimental group demonstrated higher achievement than did the control group.

Observation

The experimental observations revealed numerous findings worth exploring: (1) The students had high expectations of the robot. Whenever some delays or problems with the robot occurred, they began to lose concentration toward the system, indicating a critical interaction between the students and the robot. (2) The voice reply of the

Table 4. *T*-test of pretest and posttest with control and experimental groups.

					Two-tailed *t*-test			
Test	Groups	*N*	Mean	SD	*F*	*t*	*df*	Sig. (*p*)
Pretest	Control	30	36	25.41	0.646	0.421	58	0.675
	Experimental	30	38.67	23.60				
Posttest	Control	30	68	20.81	0.558	2.249	58	0.028
	Experimental	30	80.83	23.33				

robot affected student emotions. For instance, whenever the robot dictated vocabulary, the students repeated it, which means the system design of the responsive voice plays a vital role. (3) The students focused too much on robot actions and ignored messages displayed on the screen. The experiment revealed that an appropriate sound reminder helped attract student attention. (4) Finally, the contest mechanism motivated the students to learn. During learning activities, the group that hid the monkeys focused on the finding group and felt happy when the finding group failed to find the monkeys. The finding group discussed their strategies to find the monkeys faster than the other group did, while the hiding group hid the monkeys in the other room. Adding a timer and scoreboard to the system could increase excitement and motivate students to compete with each other.

Discussions

The implication of this study involves materializing the concept of a learning companion from a software agent to a real robot. The learning companion is an active subarea of artificial intelligence in education. However, most studies on learning companions have been implemented using software agents or tools. We observed the effects on learners after materializing a learning companion, and the result is similar to the finding that children learning with robot or animal learning companions display higher concentration than do those learning with a virtual companion (Chang, Lee, Chao, Wang, & Chen, 2010). Children could also engage deeply and feel more enjoyment with the DLP. One of the reasons might be that control is a critical factor influencing children's motivation, and the voice-controlled robot provides the opportunity for them to speak. Moreover, as the surrogates for students to imagine they are accomplishing real-life missions, robots could be a vital element of authentic learning in the classroom.

This study had several limitations. First, the disciplines necessary to apply a DLP must be more thoroughly explored. This study was focused mainly on our experience in EFL. Second, the duration of the study was not sufficiently long to observe the change of the novelty effect. The content for a DLP should be extended to cover requirements of an entire semester. Third, the speech synthesis and speech recognition used in this study were based on Standard English. However, the participants in this study spoke with native Chinese-speaking accents and may have needed to practice communicating with the robot. Moreover, although the voice recognition accuracy used in this study is extremely high, many children speaking at the same time would create a problem. Fourth, the limited capacities of the robot might constrain the instructional design and the possibility of student learning. However, with advances in technology, the higher capacities of robots at lower prices would make the proposed framework more useful.

Conclusion

This study was conducted with the intention of encouraging students to learn in an authentic learning environment in the classroom by proposing a learning platform, the DLP. The DLP successfully conveyed information of authentic context to the audience and elicited learner feedback. The experimental results show that students using the DLP significantly learned the usage of more English words. Many students agreed that the DLP helped them focus on the learning content, increased their willingness to participate in class activities, and helped them enjoy the process of learning. A comparison of the pretest and posttest scores between students who used the DLP and those who did not clearly shows that those who used the DLP scored higher than did the other students. The results of this study reveal that the technology provides an affordable near-authentic learning environment and creates authentic learning experiences in the conventional classroom. Additional empirical studies would be valuable in constructing an authentic learning environment in classrooms.

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