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Do Learning Styles Matter? Motivating Learners in an Augmented Geopark

Tien-Chi Huang, Mu-Yen Chen* and Wen-Pao Hsu
Department of Information Management, National Taichung University of Science and Technology, Taiwan
// tchuang@nutc.edu.tw // mychen.academy@gmail.com // andrew780110@gmail.com
*Corresponding author

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ABSTRACT

Augmented reality (AR) technology has recently been applied to outdoor learning in an attempt to overcome the drawbacks associated with traditional teaching environments. This study conducted an experiment designed to examine how augmented reality (AR) technology in mobile devices can be used to generate virtual objects to create a context-aware, AR-enabled guided tour application for outdoor learning. The participants were 70 elementary school students (average age: 11 years), who were randomly divided into control and experiment groups. The results showed the proposed system provided learners with a friendly, interactive interface and rich, engaging media to improve learning performance and stimulate the students' internal motivation to learn. The system's quantification of the learning motivations noted in Keller's ARCS model and Kolb's learning style theory can be used to improve the design of the learning materials. In conclusion: (1) The proposed system and activity helps stimulate learning intention via the pursuit of outdoor learning objectives, (2) the AR technology provides learners with contextual information related to the outdoor learning environment, and (3) the benefits of the proposed model do not differ for students with different learning styles.

Keywords

Augmented reality, Ubiquitous learning, ARCS, Motivation, Learning styles

Introduction

Authentic learning activities have been proven to be an effective method by which to improve students' problem-solving skills and learning achievements (Chen & Lin, 2016; Herrington & Oliver, 2000; Hwang et al., 2010). Fieldwork in geology—a form of authentic learning—has become one of the main activities to focus on the natural environment in todays' school education systems (de Barros et al., 2012). Among school subjects, geology places the most emphasis on observation and authentic learning, in which rich geological natural resources can stimulate students' intention to learn. However, the traditional one-guiding-many method of teaching geology outdoors usually fails to arouse the individual's motivation to learn, and does not provide content that facilitates individual exploration by the student.

Recent studies have stated that integrating innovative digital technology with the learning of geology in an outdoor setting can enable students to explore actual geology in depth (Di Serio et al., 2013; Moutinho et al., 2015). Augmented reality (AR) technology, which was developed over the last few decades and has became popular in educational technology research, is able to overcome the key weakness of authentic learning: the lack of adaptive systematic material (Huang et al., 2016a). Given the ability to create a ubiquitous learning environment, the approach can be an efficient approach to increase student intention, letting education to arise in authentic contexts outside the classroom.

Disseminating digital content via educational technology makes it possible to arouse students' motivation to learn. The ARCS model of motivational design emphasizes the four key elements of motivation: Attention, Relevance, Confidence and Satisfaction (Keller, 1987a; Keller, 1987b). The model elaborates the content of motivation, which allows us to improve educational projects and teaching quality (Keller 1999). Besides learning motivation, learning style is another issue of concern in the learning process (Kolb, 1976). Although digital learning can support adaptive learning, the extent to which individual differences influence the learning outcome and even the motivation remains a question (Terrell, 2002). According to Kolb (1976), individual differences in information perception and information processing form four types of learning styles: diverging, assimilating, converging and accommodating. Different learning styles may bring about different outcomes for e-learning activities, particularly in terms of e-learning motivation.

In an authentic Geopark, an AR system might be able to improve learning effectiveness and motivation for learners who have different learning styles. Thus, this study develops an AR-based ubiquitous learning system and applies it in Taiwan's National Geopark. In other words, this study attempts to realize systematic, personalized learning in an authentic learning environment using AR technology. In view of the above research purpose, the following research questions are addressed in this study:

- Does the AR u-Geopark learning system improve learning achievement?
- Do students with different learning styles achieve the same level of learning when using the AR u-Geopark learning system?
- Did the AR u-Geopark learning system augmented by AR motivate students?

Literature review

AR for ubiquitous learning

Ubiquitous learning (u-learning) is "anywhere and anytime learning." U-learning systems are designed and implemented followed by situated learning theory, which states that effective learning is best achieved by settling questions and obtaining knowledge from authentic experiences (Wang et al., 2015). The u-learning process has four advantages over traditional teaching methods. First, it allows access to information and sharable content via a mobile device (Hwang et al., 2011). Second, allows learning to happen at any location, indoors or outdoors (Klopfer et al., 2002). Third, the learning content is presented in authentic contexts (Liu et al., 2009). Fourth, the approach allows for the accumulation of a portfolio showing the individual's learning progress (Glasersfeld, 1990). Situated learning theory also states that learning motivation comes from the stimuli within the authentic environment. However, once students' learning motivation is aroused, an instructor faces the disadvantage of the lack of systematic information in the authentic environment.

To overcome the problem, augmented reality (AR) technology, which can combine virtual objects with the real world on a mobile device, is usually adopted in authentic learning environments. While the student is immersed in the real environment, virtual objects are produced via mobile devices or cameras and computers. Students can learn the study subject by using virtual objects on the equipment (Okita, 2014; Huang et al., 2016a; Huang et al., 2016b). Since mobile devices are context-aware in the real environment, learners can use them to understand the information available in the real world, and form a better understanding of the surrounding environment (Yang 2015). Therefore, the application of AR in this study of u-learning is summarized as follows:

- *Integration of the real-world and AR learning:* The use of AR technology allows learning materials to be more diverse and rich. With an integrated information system, students can relate the learning materials directly to the real world (Tsai et al., 2011), and the context-aware environment helps facilitate their understanding of the subject (Gutiérrez et al., 2010).
- *Development of an adaptive learning strategy with AR technology:* When students encounter a learning system with a complicated interface, their good intentions (deeper learning) are often dampened by the complexity of operating the system. Creating learning objectives based on the student's current location allows the learner to use the system with ease, increasing learning effectiveness (Chen & Lin, 2016).
- *Creation of an innovative u-learning application:* Improving on the traditional learning model by using mature AR and multimedia streaming technologies, this innovative learning model allows students to extend their education via self-learning in context (Zhu & Jin, 2012). Students do not need to memorize texts; their study subjects are generated by a combination of the real world and virtual objects, allowing learners to deepen their prior knowledge (Ng, 2012).

AR and ARCS motivation model

In 1983, Keller proposed the ARCS model of motivational design which helps us to understand learners' motivations and how to stimulate their desire for knowledge. The model is divided into four categories, namely Attention (A), Relevance (R), Confidence (C), and Satisfaction (S) (Keller, 1987a; Keller, 1987b). The first step is to understand what catches students' attention in this motivation process, and to explore those triggers in depth. The subject matter and curricula are then tailored to relate closely to the individual student's motivations. As they complete these learning tasks, their confidence builds. The learning process has to be both educational and interesting in order for students to concentrate on the subject materials (Gutiérrez et al., 2010). Students' motivation is assessed via a questionnaire.

Recently, Hassan et al. (2012) adopted the ARCS model to investigate learning performance in distance learning. Their results indicate that AR or context-aware learning objectives increase students' willingness to learn continuously. The adoption of AR technology motivates students by drawing their attention with augmented information, providing relevant content according to their current location, building learning confidence, and satisfying them with rich information. Therefore, compared to traditional learning models, the AR assisted model proved more effective in enhancing both the learning and the willingness to learn (Cheng & Su, 2012; Di Serio et al., 2013).

Learning style and individual differences

Learning style is one of the main concepts involving individual differences in learning. In a u-learning environment, multimedia is adopted in the learning process, and differences in preference regarding information processing may influence the students' achievement.

Kolb proposed the theory of learning style (Kolb, 1976) which was classified into the two dimensions of data grasping and data transformation, and these dimensions encompass four independent learning stages. Data grasping includes concrete experience (feeling) and reflective observation (watching). Data transformation includes abstract conceptualization (thinking), and active experimentation (doing). These four learning stages are also correlated to four learning types. Throughout the four stages, each of the four different types of learners choose the learning model which they find most favorable (see Table 1).

Table 1. Kolb's learning styles

Learning style	Characteristics
Diverging	(Concrete, Reflective) • Emphasizes innovative and imaginative approaches to doing things • Interested in people and tends to be feeling-oriented • Richly imaginative; will increase focus when the subject is found to be interesting
Assimilating	(Reflective, Abstract) • Good at independent inductive reasoning and prefers theories and logic • Cares more about thoughts and abstract theoretical concepts
Converging	(Abstract, Active) • Emphasizes problem solving and the practical application of ideas • Performs best when solving problems that have a single ideal answer
Accommodating	(Active, Concrete) • Good at hands-on learning, learning by doing • Comfortable with new learning models and will not eschew new learning methods

The effectiveness of a given learning method depends on the student's learning style. When the student is guided in a way that matches his or her learning style, learning is less burdensome. For example, diverging and accommodating learners find it difficult to sit alone in their seats to learn. A gaming scenario stimulates these types of students' motivation to learn, because they understand the message and gain knowledge via doing (Girvan et al., 2013). In contrast, learning in a solitary environment may help some converging and assimilating learners. These types of learners can easily focus in a classroom. When doing field studies outside of the classroom, they may feel the need for a separate space for reading in order to digest the content (Konak et al., 2014).

To investigate the relationship between e-learning and learning performance, Konak et al. (2014) adopted Kolb's Experiential Learning Cycle as a framework to design hands-on activities in virtual computer laboratories. They found that such activities enhance student learning outcomes. In this study, Kolb's learning style is adopted to investigate individual differences in u-learning motivation and achievement.

System design and architecture

This research integrates a context-aware ubiquitous learning environment and AR techniques, using content based on the Yehliu Geological Park. The proposed u-learning system incorporates radio frequency identification (RFID) and augmented reality (AR) technologies in mobile devices, allowing the learner to immediately access supplementary information regarding the geological objects observed in the park. This section describes the hardware and software requirements of the proposed system.

In this research, context-aware technology was used to allow users to follow learning activities along a predetermined route, using the augmented reality features to engage in image memory-based learning to increase comprehension and retention. Figure 1 shows the system architecture.

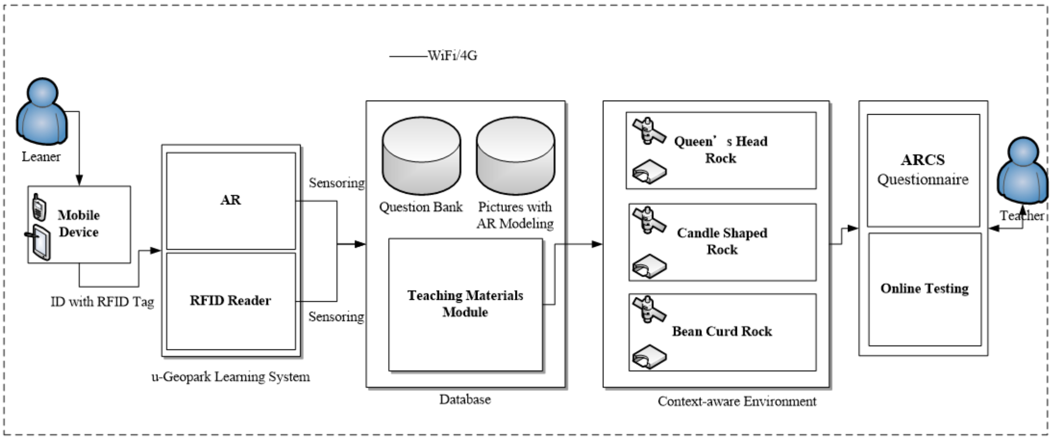

Figure 1. Ubiquitous learning system architecture diagram

Teachers can use a classroom version of the AR system to introduce students to the system and its content in a classroom setting. In traditional classrooms, students learn about nature through text and pictures only, making it difficult for them to truly understand the essence of the natural sciences. However, using the proposed system, the teacher in the classroom can lead students through the supplemental teaching material at various difficulty levels. The teaching materials module allows teachers to select an appropriate level of subject difficulty. The teaching materials are classified according to level of difficulty. It is considered an aggregate of teaching units, including a topic name and its geology content, and the degree of difficulty in association with other units. The teaching units are also designed by teachers and are based on the concepts of geology knowledge. Teachers also constructed the tests that assess the student's mastery of each teaching unit. In the system development phase, these tests were executed and obtained the degree of difficulty parameters. When learners finish Teaching Unit 1 of the instruction, they subsequently experience their first assessment using their tablets. The system then calculates their test scores. If a student fails to pass, the system will recommend other material regarding the same concept at the appropriate degree of difficulty. Using wireless technology, the system will transmit the suitable materials directly to the student's tablet. On the other hand, if the student passes the exam in Teaching Unit 1, the student can continue the enrichment activities with additional related topics. On the other hand, the content management module allows teachers to easily swap different activities in or out of the course. Students can also use ancillary and supplemental teaching materials in the AR environment, using geographical location information to increase their learning efficiency.

From the learner's perspective, the system logs all student activity, automatically adjusts the scope of subjects, selects an appropriate learning difficulty level, and updates parameters according to the student's search results. While navigating the learning path, students can engage with one topic after another. In the traditional classroom, learners often have difficulty keeping pace with a teacher's presentation because of a lack of understanding. Using the proposed u-learning system, students can repeatedly engage with the instructional material at their own pace, thus developing a familiarity of the topic.

Augmented reality interface and operations

On the system entry screen, students see four options. They can choose the option that best suits their needs, as shown in Figure 2. The upper left option is (1) "Personal Information," (2) the upper right is "Learning Portfolio," (3) the lower left is "Augmented Reality," and (4) the lower right is the "Natural Encyclopedia." "Learning Portfolio" is selected to show whether the goal of individual learning has been completed.

Selecting "Augmented Reality" and the corresponding subject 1 "Queen's Head Rock" allows the user to select D'Fusion to display the AR model corresponding to the labels, as shown in Figure 3(a). Clicking on the side buttons reveals popup information, as shown in Figure 3(b).

If students are not clear about the observation requirements of the learning objective during the process, they can select "Natural Encyclopedia." The popups offer more information regarding key features of the object being observed.

Figure 2. Options of the ubiquitous learning system and learning portfolio

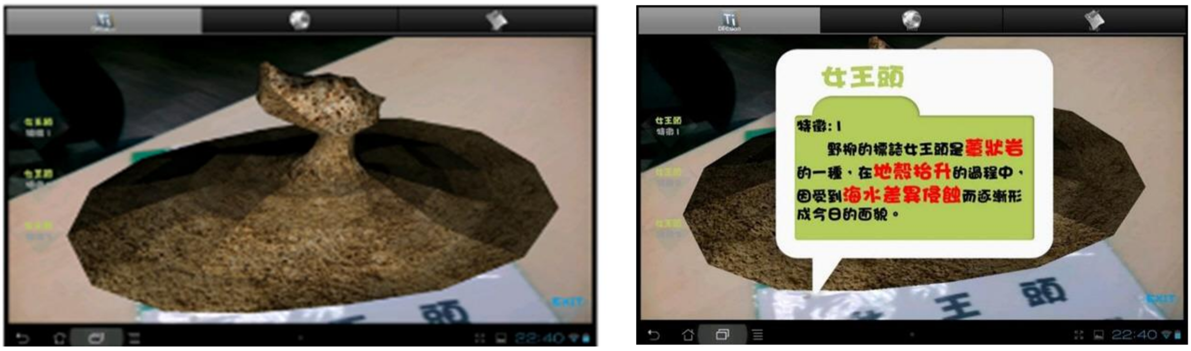

Figure 3. The "Queen's Head Rock" with AR technology

Research design and evaluation

A three-phase quasi-experiment was performed on students in the 4th (n = 25), 5th (n = 23) and 6th (n = 22) grades (N = 70; male = 39, female = 31), using the proposed AR u-Geopark system. The participants were from a public elementary school in northern Taiwan. All students had 1 to 2 years of experience using tablets at school or at home. Figure 4 shows the research chronology.

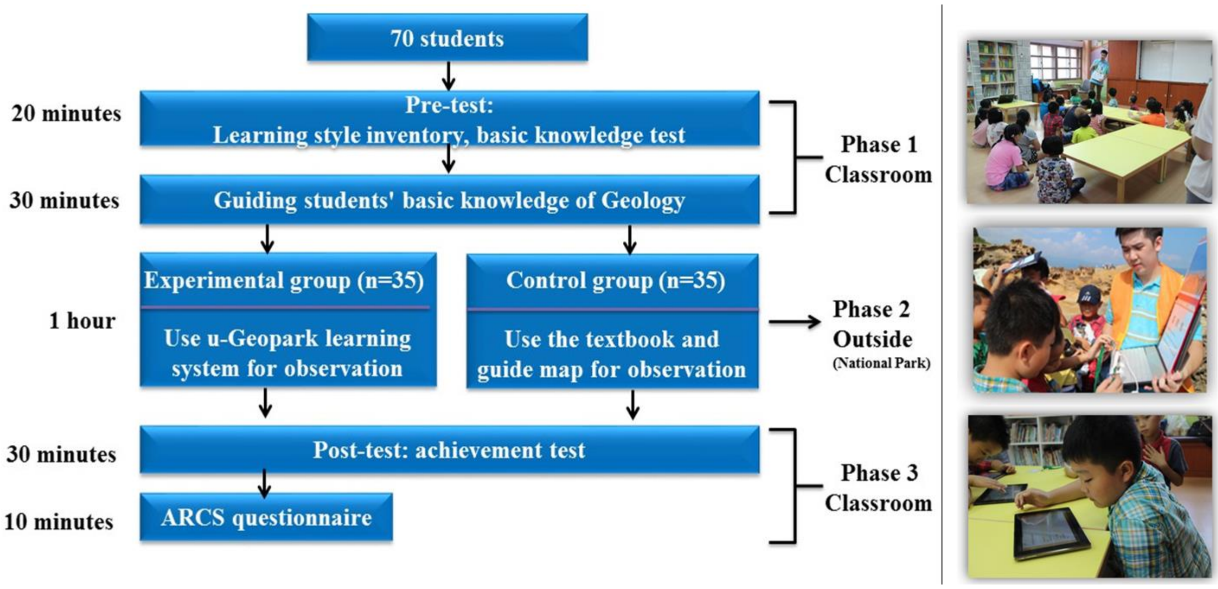

Figure 4. Research chronology

The 70 students were randomly divided these into experimental and control groups. Both groups had students from each of the three grade levels. First, 70 students were required to take pre-test to test their basic knowledge of these patterns and to assess their learning style. This study adopted the "Kolb learning style inventory" (KLSI,

V. 3.1) to determine students’ learning style of the experimental group. The Cronbach’s alpha of the four dimensions are .82, .73, .83 and .78 (Kolb, 1985). After “Kolb learning style inventory” was fulfilled, there were 13, 2, 5, and 15 learners belong to the diverging, assimilating, converging, and accommodating learning styles.

In Phase 1, teachers adopted traditional teaching approach in the classroom to carry on geology concepts, referring to some of Yeliu’s specific geological features: “Queen’s Head Rock,” “Candle Shaped Rock,” and “Bean Curd Rock.” This research was conducted in Yehliu Geopark which is comprised of many different kinds of landscapes and rocks.

Learning materials	Experimental Group	Control Group
Introduction		
Queen’s Head Rock		

Figure 5. Learning materials for the two groups

In Phase 2, the two groups of student proceeded with the experiment separately, and two experienced teachers instructed the two groups regarding what to observe and where to go. The students in the experimental group used the system to observe the objects. When they reached the observation site, they could observe the authentic objects and use the device with RFID reader to capture augmented learning information via sensing RFID tags that were built on the site. The learning information was accompanied by AR objects. The control group used the traditional commentator-guided method to observe the same objects. The learning information for the control group was presented on paper-based materials (e.g., brochures, information sheets). The two kinds of learning materials are shown in Figure 5. This activity spent 60 minutes for the two groups. For the control group, they tried to discover the objective geological subjects adopting textbook and a guide map. In the meantime, the experimental group engaged the learning actives by adopting the u-Geopark learning system. The learning subjects were “Queen’s Head Rock,” “Candle Shaped Rock,” and “Bean Curd Rock” and the experimental infrastructure was the Yehliu Geological Park, as shown in Figure 6.

In Phase 3, both the experimental and control groups come back to the classroom and fulfilled a post-test. In addition, the experimental group filled in the five-point-Likert-type ARCS questionnaire to assess how effectively the system increased learning motivation and performance (Appendix A) (10 minutes). In general, the purpose of the post-test was to access students’ comprehension of the basic geology of Yehliu Geopark and their knowledge of “Queen’s Head Rock,” “Candle Shaped Rock,” and “Bean Curd Rock.” And the ARCS questionnaire of this study was designed based on Keller (2010), Hassan et al. (2012), Cheng & Su (2012), and Di Serio et al. (2013). We compared these two groups in terms of learning motivation and learning effectiveness, and analyzed the learning styles of different learners to see how such information could help increase learning effectiveness.

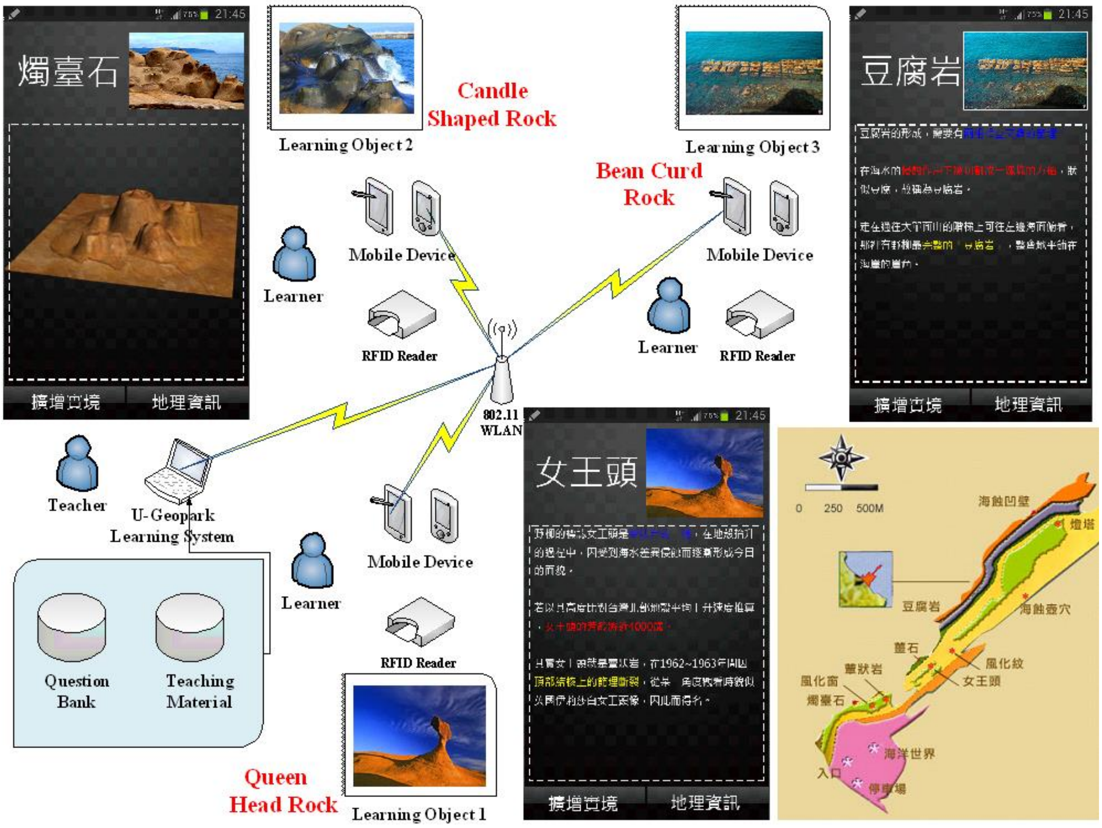

Figure 6. Experimental infrastructure at Yehliu Geological Park

Results

The AR u-Geopark learning system developed in this study facilitates student learning at the Yehliu Geopark. After the learning experiment was completed, the learning styles and motivation level of the students were analyzed to explore the impact of different learning styles on learning effectiveness and the willingness to learn. The pre-test and post-test scores of the samples are shown in Table 1.

Table 1. Mean grades and *t*-test of achievement tests for each learning activity

	Numbers	Pre-test	Post-test	t
Experimental Group	35	54.64	74.86	-7.092^{**}
Control Group	35	55.71	68.00	-3.34^{**}
t		0.25	-2.707^{*}	

Note. $^{**}p < .01$.

The difference in the pre-test scores of the two groups is not significant, while the t test between these two groups in the posttest (t =-2.707, $p < .01$) were significant. Meanwhile, the difference between pre-test and post-test in the experimental group is significant (t = -7.092, $p < .005$), so is the control group (t = -3.34, $p < .005$). That means the devised learning activities are exactly helpful to stimulate students' learning achievements.

A pair-sample t-test was used to analyze the significance of the pre-test and post-test scores for each of the four learning style groups as shown in Table 2. The results show that the differences in pre- and post-test scores for diverging and accommodating learners are both statistically significant, and the p-value for each is below 0.05. The results of the Kruskal-Wallis test for pre-achievement and post-achievement test showed no significant difference in four learning style groups ($p > .05$), respectively.

According to past literature (Terrell & Dringus, 2000), we further divided four group (learning style) into two sets: information-perceiving and information-processing. The first set is concrete (Diverging and Accommodation) vs. abstract approach (Assimilating and Converging). The second set is reflective (Diverging and Assimilating) vs. active approach (Accommodation and Converging). The independent sample t-test results show that there are no differences in both sets in Table 3.

Table 2. Difference tests for achievement testing for the four Learning Styles

Kolb's Learning Style	Paired variation					Pair-sample			Independent-sample Ach. Kruskal-Wallis	
	Mean	*SD*	SEM	95% Confidence Interval of Error		*t*	*df*	Sig (two-tailed)	Pre-test	Post-test
				Lower	Upper					
Diverging	-20.62	16.81	4.66	-30.77	-10.46	4.42	12	.001*	χ^2=2.75 *df*=3	χ^2=1.07 *df*=3
Assimilating	-40.00	28.28	20.00	-294.12	214.12	2.00	1	.295		
Converging	-14.20	19.87	8.89	-38.87	10.47	1.60	4	.185		
Accommodating	-21.33	17.88	4.62	-31.23	-11.43	4.62	14	.000*		

Note. $^*p < .05$.

Table 3. t-test of achievement performance for two participant sets

	Kolb's Learning Style	Mean	*SD*	*t*	*df*	Sig (two-tailed)
First set:	Concrete (Div & Acc)	54.02	17.4	-.46	33	.66
Pre-test	Abstract (Ass & Con)	57.14	15.9			
First set:	Concrete (Div& Acc)	75.36	11.4	.70	33	.50
Post-test	Abstract (Ass & Con)	72.86	7.6			
Second set:	Reflective (Div & Ass)	53.3	18.0	-.39	33	.70
Pre-test	Active (Acc & Con)	55.6	16.5			
Second set:	Reflective (Div & Ass)	74.0	11.8	-.40	33	.70
Post-test	Active (Acc & Con)	75.5	10.0			

In Table 4, the outcome of ARCS scale presents that students' motivation towards the "augmented Geopark learning activity" is high, the average mean value is between 4.21 and 4.39. Then, the students' motivations were analyzed separately according to their learning styles. The degree of satisfaction was crucial to their motivation in three learning style groups: the diverging, the assimilating, and the accommodating groups. The converging group scored highest in attention (m = 4.54) which is the second high among the four learning styles in average score.

Table 4. Mean grades of four perspectives for the ARCS questionnaire

Learning style	ARCS			
	Attention	Relevance	Confidence	Satisfaction
All	4.34	4.26	4.21	4.39
Diverging	4.21	4.25	4.20	4.45
Assimilating	4.79	4.75	4.60	4.80
Converging	4.54	4.30	4.40	4.24
Accommodating	4.32	4.16	4.09	4.33

Discussion

Learning achievement of AR u-Geopark learning system

In this study, the control group adopted a relatively traditional strategy like reading instruction paper, while the experimental group learned with the ubiquitous AR system. An achievement test is a test of developed skill or knowledge. The most common type of achievement test is a standardized test developed to measure skills and knowledge learned in a given grade level, usually through planned instruction, such as training or classroom instruction (Koretz, 2002). In advance, achievement test scores are often used in an educational system to determine what level of instruction for which a student is prepared (Chen & Huang, 2012; Chen & Lin, 2016).

In this research, we used the pre-test and post-test for both groups, the average testing score is improving from 54.64 to 74.86 of the experimental group, in the meantime, the average testing score is improving from 55.71 to 68.00 of the control group. The descriptive statistics shows there is a significant increase for the testing score between pre-test and post-test. In advance, the difference between pre-test and post-test in the experimental group is significant (t = -7.092, p < .005), so is the control group (t = -3.34, p < .005). That means the devised learning activities are exactly helpful to stimulate students' learning achievements.

Learning performance of different learning styles

In Table 2, the results show that the "AR u-Geopark system" improved students' learning achievement, especially for those with diverging and accommodating learning styles, both of which are concrete-oriented style. The outcome shows that the real environment activity is more attractive for students who prefer concrete experiences, and the system provides dynamic, interactive information for their education. The differences of pre-test and post-test scores among the four groups did not reach the level of significance. In other words, when immersed in the same process in an AR-assisted ubiquitous learning environment, learning achievement levels do not differ among the different learning styles.

However, the result is different from the related literature. Past studies have examined learners' achievement while using hypermedia and online learning systems according to their learning style (Di Serio et al., 2013; Terrell & Dringus, 2000; Terrell, 2002; Wei et al., 2015). They stated that in a digital learning environment (non-face-to-face), the "abstract" approach learners performed better than the "concrete" approach learners. In this study, the "concrete" approach learners (diverging and accommodating) improved significantly after the u-learning experience. This indicates that while all the learners are exploring in an authentic environment, the concepts can be concretize by presenting images of different angles on the mobile interface (Chen & Chen, 2017). Therefore, we suggest that AR may provide more benefits to learners with a concrete approach than to those who learn with an abstract approach. Besides, we conclude that the AR possesses great different features comparing to other types of e-learning technology, it helps learner to connect the concrete environment and abstract concept. Comparing to the environment, we think to assess students' characteristic and give them the most proper e-learning assistance are the key issues of this study.

Motivation in AR U-learning environment

In Table 4, all four groups have a high average level (lowest mean = 4.21) of motivation in all four aspects (A, R, C, and S). The degree of learning satisfaction is critical to their motivation while learning with the AR system in a ubiquitous environment, and this result is in line with Huang et al. (2015).

ARCS model is a process of elements which are able to stimulate learners' motivation. The converging learners enjoy problem solving in which observation with attention is the primary step. For the converging learners, this explains why attention is the key incentive of learning with AR system. Otherwise, the diverging, assimilating, and accommodating learners have higher levels of satisfaction regarding the activity, compared to the other three elements. Interestingly, although learners possess different learning preferences (diverging learners like creative materials, assimilating learners enjoy logical thinking, and accommodating learners prefer real experiences), they all self-report high levels of satisfaction in regards to the AR system. In this study, we found out that the 3D presentation in the system satisfied the diverging learners' innovative need, the detailed explanation about the Geopark sites in the system fulfilled what assimilating learners want, and the activity was conducted in an authentic environment where accommodating learners could explore. The AR system and the ubiquitous learning environment aroused the motivation to learn, even among students whose learning style orientations are different. In other words, the diverse needs of the students were satisfied by the characteristics embedded in the AR which assisted the learning activities.

As a form of digital learning, a key feature of the AR system differs significantly from other kinds of digital learning: the connection with a situated, authentic environment. To be more specific, the present learning environment is a ubiquitous environment with AR technology installed. The AR system augmented the authentic environment, allowing the co-existence of real interactions and abstract information, which simultaneously satisfy students with different learning styles, enhancing their learning achievement. Future studies could further focus on exploring the relationship between learning style and u-learning achievement in different subjects.

Conclusion

This research integrates a context-aware ubiquitous learning environment and AR techniques, using content based on the Yehliu Geological Park. The proposed AR u-Geopark learning system allows the learner to immediately access supplementary information regarding the geological objects observed in the park. After the learning experiment was completed, the learning styles and motives of learners were analyzed to explore the impact of different learning styles on learning effectiveness and the willingness to learn. The results show that the proposed system can improve learning performance and stimulate students' internal motivation to learn.

In this research, there are several limitations and can be considered improving in the future works. First, sampling was carried out in the Yehliu Elementary School of New Taipei City, an area in north Taiwan nearby the Yehliu National GeoPark. Future researches can be enlarged to involve more samples or other grade schools to differ from our research sample. Second, we recommended to apply the proposed u-learning approach to other outdoor courses and evaluate the learning performance of the teaching activities. Third, we divided the research sample into experimental group and control group. Besides, we used the pair-sample *t*-test, Kruskal-Wallis test, and independent sample *t*-test to assess the learning outcomes. Therefore, more statistical analysis or structural equation modeling can be considered. Finally, we used the ARCS model to understand the learning motivation under the u-learning environment. However, other motivation models or theories, such as achievement motivation theory, attribution theory, and self-efficacy theory can be considered adopting to extend the explanatory capacity of this research.

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Appendix A

ARCS Questionnaire

A

1. What interests me is the learning program using the 3D model system.
2. The content of the learning program of the 3D model system is very appealing to me.
3. The content of the learning program of the 3D model system is vivid and it makes me more focused in class.
4. The interpretation of the 3D model system helps me stay focused for longer periods of time.
5. Personally operating the digital teaching aids stimulates my curiosity.
6. Using the 3D model system to learn the course knowledge surprises me.
7. The use of 3D model system helps me become more focused on learning.

R

1. The goal is consistent with what I learn in class; I believe I can understand the learning content.
2. The comprehensive teaching materials help build my confidence.
3. I felt fulfilled and satisfied when I completed this learning program.
4. The diversity of learning activities makes me feel more interested.
5. The diagrams and examples in the 3D model system help me understand more about the learning content.
6. The content is worth understanding when studying the subject using the teaching material from the 3D model system.
7. The goal is consistent with what I learn in class; I can learn in my daily ordinary life.
8. The content of this course will be useful to me.

C

1. When I first saw the materials, they made an impression on me.
2. Good teaching materials help me build confidence.
3. After using the system, I have more confidence in my learning ability.
4. After using the teaching materials of the 3D model system, I am more confident that I will pass the exam.
5. With the diversified 3D model system for learning, I am more confident that I can learn comprehensively.

S

1. Upon completion of this program, I felt fulfilled and satisfied.
2. I am pleased to participate in this program, and I would like to continue to use the system for after-school learning.
3. I really liked learning this subject.
4. I was satisfied and had a sense of accomplishment when I completed each subject.
5. The curriculum of this 3D model system is vivid, and I found it pretty novel.