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Effects of teaching and learning styles on students' reflection levels for ubiquitous learning

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A B S T R A C T

Ubiquitous learning (u-learning), in conjunction with supports from the digital world, is recognized as an effective approach for situating students in real-world learning environments. Earlier studies concerning u-learning have mainly focused on investigating the learning attitudes and learning achievements of students, while the causations such as learning style and teaching style were usually ignored. This study aims to investigate the effects of teaching styles and learning styles on reflection levels of students within the context of u-learning. In particular, we investigated the teaching styles at the dimensions of brainstorming and instruction and recall and the learning styles at the dimensions of active and reflective learning. The experiment was conducted with 39 fifth grader students at an elementary school in southern Taiwan. A u-learning environment was established at a butterfly ecology garden to conduct experiments for natural science courses. The experimental results of one-way ANCOVA show that those students who received a matching teaching–learning style presented a significant improvement in their reflection level. That is, matching the learning styles of students with the appropriate teaching styles can significantly improve students' reflection levels in a u-learning environment.

1. Introduction

The convenience and effectiveness of employing mobile devices in learning activities has grabbed the attention of educators around the globe (Uzunboylu, Cavus, & Ercag, 2009). Mobile devices and wireless Internet technology enable learners to learn using a variety of digital resources from anywhere in the world at anytime. This new way of learning is commonly known as ubiquitous learning or u-learning (Huang, Lin, & Cheng, 2010; Hwang, Kuo, Yin, & Chuang, 2010; Hwang, Tsai, & Yang, 2008; Liu & Chu, 2010; Liu & Hwang, 2010; Yang, 2006). Studies have suggested that u-learning has the potential to increase learning efficiency (Chu, Hwang, Huang, & Wu, 2008; Chu, Hwang, & Tsai, 2010; Hwang, Yang, Tsai, & Yang, 2009; Ogata & Yano, 2004; Wei & Chen, 2006).

However, when a different instruction method or approach to learning (e.g., u-learning) is introduced to students, they are often requested to adapt themselves to the new methods without consideration of their cognitive and affective preferences (Åkerlind & Trevitt, 1999). Hung, Bailey, and Jonassen (2003) mentioned that learners may experience frustration during the transition from an accustomed learning approach to a different one. This frustration is almost inevitable for students who are uncertain of their roles, their duties and the evaluation methods in their new learning processes at the early stage of transition (Jost, Havard, & Smith, 1997), but students' discomfort lessens as they become familiar with the new approach and their responsibilities in the learning process (Chu, Hwang, Tsai, & Tseng, 2010; Hung, Lin, & Hwang, 2010; Schultz-Ross & Kline, 1999).

One possible solution that reduces the tension created by the transition from the old to the new instruction/learning approach is to carefully consider students' learning patterns or styles and incorporate this in the design of the new instructional approach or tool (Graf, Liu, & Kinshuk, 2010; Hall & Bannon, 2006; Hunt, Thomas, & Eagle, 2002). This in turn helps students appreciate the strengths of the new approach or tool, and encourages active involvement and participation. Learning styles refer to the set of preferences individual students

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have for perceiving, assimilating, and interpreting incoming information (Curry, 1983; Felder & Soloman, 1997; Kolb, 1984). Among other style theories, Curry's (1983, 1987) onion model illustrates how different learning traits can be conceived as four layers. From the inner to the outermost layers, these include layers of cognitive personality, information processing style, social interaction, and instructional preference. This study was particularly interested in the information processing layer because it concerns which intellectual approach individuals prefer when assimilating information (Cassidy, 2004; Swanson, 1995).

There have been several measuring tools developed for evaluating students' learning styles at the level of information processing. For example, based on Kolb's model (Kolb, 1976, 1984, 1985) of experiential learning, Felder and Silverman (1988) modeled students' learning preferences and suggested that for each learning style there is a corresponding teaching style. Felder and Silverman suggested that when a teaching style (i.e., an instruction method) is matched to a corresponding learning style of a particular student, that student benefits enormously. This notion of matching teaching and learning styles is consistent with the fundamentals of adaptive learning strategies, in that instruction should be adaptive to students' cognitive traits (e.g., Brusilovsky & Maybury, 2002; Chang, Kao, Chu, & Chiu, 2009; Chen, Wei, Wu, & Uden, 2008; Manouselis & Sampson, 2002; Masthoff, 2002). This study's authors were particularly interested in the students' preferences of processing internal experience on the active–reflective continuum and the suggested teaching styles, either "brainstorming" or "instruction and recall", for their functional relevance to the reflection process the student undertakes in a learning activity.

Reflection has been recognized as being a metacognitive process that examines and explores constructed knowledge and experience (Boyd & Fales, 1983; Dewey, 1933). It plays an important role in the learning process because it increases learning outcomes (McNamara, 2004; McNamara, O'Reilly, Best, & Ozuru, 2006). Instructors usually facilitate students' reflective thought by asking questions that stimulate reflection, and providing feedback to questions generated by students while they reflect (Chi, de Leeuw, Chiu, & Lavancher, 1994; Davis, 2000). A contemporary trend in the realm of higher education stresses the importance of developing students' reflective ability in order to prepare them to be adaptable within increasingly changing environments (Chen, Kinshuk, Wei, & Liu, 2010; Chen, Wei et al., 2008; Harvey & Knight, 1996). However, the best manner in which to improve learners' reflective ability has yet to be fully elucidated. This is especially true for educational situations in which students are engaged in off campus learning activities.

This study investigated the effect of this reflective process with respect to the matching of the teaching style the students received (i.e., "brainstorming" or "instruction and recall") and their learning styles (i.e., active or reflective). This study was conducted with the supposition that students receiving a teaching style which matched their instruction and recall style would perform better in their reflective thinking. A u-learning environment was established in a butterfly ecology garden for conducting experiments for natural science courses.

2. Literature review

2.1. Learning styles and teaching styles

Learning styles refer to one's preferences in processing external information or internal knowledge and experience. Felder and Soloman (1997) created a five-dimensional model of learning styles: perception, input, organization, processing and understanding. Each dimension consists of two different preferences, and one's learning style is determined by the answers given for each dimension. The dimension of perception concerns the type of information one preferentially perceives, which can be either a type of external sensory information (e.g., sights, sounds, physical sensations) or internal intuitive information (e.g., insights, possibilities). The dimension of input refers to the sensory channel with which one can most effectively perceive external information. This can be either through visual perception (e.g., pictures, demonstrations) or auditory perception (e.g., words, sounds). The organization dimension describes the form of information one feels comfortable with. These forms can be either inductive (i.e., the underlying principles are inferred on the basis of given facts and observations) or deductive (i.e., consequences and applications are inferred on the basis of the given principles). The dimension of processing describes how one prefers to process information, which can be either active (i.e., through engagement in physical activities or discussion) or reflective (i.e., through introspection). The dimension of understanding concerns how one progresses toward understanding, which can either be sequentially (i.e., in continual steps) or globally (i.e., in large jumps, holistically). Researchers (e.g., Bostrom, Olfman, & Sein, 1990; Kettel, Thomson, & Greer, 2000; Pashler, McDaniel, Rohrer, & Bjork, 2009) have suggested that there is an increasing need to consider the issue of learning styles to adapt instructional strategies to learners' different needs, especially when learning in emerging, dynamic educational settings such as web-based learning environments (Graf et al., 2010; Kinshuk, Liu, & Graf, 2009; Olaniran, 2009).

This study is particularly interested in the dimension of processing because it is related to one's thinking and reasoning, as well as reflection. According to Curry's (1983, 1987) onion metaphor, the cognitive style of information processing remains stable in response to different instructional approaches and surrounding environments (Cassidy, 2004). The style of information processing, in Curry's model, influences students' preferences regarding participation in learning activities and social interactions.

Table 1
Grading criteria for evaluating students' reflection levels.

Reflection levels	Evaluation criteria	Score
Reporting	Only recalled the content of the instruction material	1
Responding	(a) Described only a few concepts	2
	(b) Described factual phenomena but without explanation	
	(c) Described personal feeling/emotion only	
Relating	(a) Stated contextual relationships	3
	(b) Explained the cause-and-effect	
Reasoning	(a) Detailed explanation of the rationale	4
	(b) Discussed the relation between the theory and practice	
Reconstructing	(a) Expressed a high order of reconstructing and reasoning	5
	(b) Systematically organized the theory, rules and experience	

Table 2
Numbers of students in each group.

Learning styles	Teaching styles	N	
Reflective	Brainstorming	10	19
	Instruction and recall	9	
Active	Brainstorming	10	20
	Instruction and recall	10	

The dimension of processes in Felder and Silverman's (1988) model was developed largely on the basis of Kolb's (1984) theory of experiential learning. It mainly concerns "the complex mental process by which the perceived information is converted into knowledge" (Felder & Silverman, 1988, p. 678). This dimension characterized learners into two groups: active experimentation and reflective observation. An active learner feels more comfortable with active experimentation than reflective introspection, which is favored by a reflective learner. Active learners learn better in situations that require them to be active experimenters; reflective learners learn better in situations that provide them sufficient opportunity to ponder the presented information. Active learners may learn well in groups; reflective learners may learn better by themselves or with a partner.

Felder and Silverman (1988) further suggested some teaching styles (i.e., instructional methods) that might benefit students in the corresponding dimensions of learning styles. For example, the instructor may well provide opportunities for active students to participate in small-group brainstorming as well as transcribing notes. Similarly, for students with reflective learning styles, some intervals during the lecture should be arranged so that the students can recall and reorganize what they have been taught.

2.2. *Reflection*

Reflection is an active, persistent and careful consideration toward self-constructed knowledge and meaning through using one's experience, action, and beliefs (Dewey, 1933; Schon, 1987). It is initiated through one's experience, thinking, consideration, and evaluation to examine and explore the concerned issues, opinions, feelings, and behaviors (Boyd & Fales, 1983; Carver & Scheier, 1998). Reflection is also a learning process which helps learners express and evaluate their attitudes and feelings, to expand their learning cognition, and is intimately related to a holistic comprehension (Boud, Keogh, & Walker, 1985; Chirema, 2007; Ladewski, Krajcik, & Palincsar, 2007; Sargeant, Mann, van der Vleuten, & Metsemakers, 2007; Ward & McCotter, 2004).

Reflection provides students with opportunities to examine the knowledge they have ingested (Etkina et al., 2010). In the classroom, reflection is often a result of teacher–student interactions in which the teacher raises certain questions to stimulate students' reflective thinking (Davis, 2000; Ladewski et al., 2007). However, when students are learning in the field or at a distance, it is not easy for the instructor to engage students in face-to-face dialectical conversations as one does in the classroom. In this case, computer technology can be of good use, in that the instructor's reflection prompts and activities that generate reflection can be delivered via students' digital devices (Bull, Quigley, & Mabbott, 2006; Saito & Miwa, 2007). The instructor can thus still facilitate students' reflective activities even when in a different location.

King (1994) used three types of questions to prompt and guide students' knowledge construction, including memory questions, comprehension questions, and connection questions. The memory questions are ones to which the answers are generally factual and can be found in textbooks, such as "How many teeth does a person have?" The comprehension questions are ones to which the answers need to be described or redefined, such as "In your own words explain the importance of A." The connection questions refer to ones to which the answers cannot be explicitly found in the text and require inference and an interpretation of multiple concepts for a full explanation, and proof, such as "Please explain the difference between A and B." Students are more likely to build new knowledge and understand the learning content when stimulated with the higher-level types such as comprehension and connection questions than with memory

Fig. 1. Learning activity of butterfly ecology.

Table 3
Descriptive statistics of students' reflection levels on the pre- and post-tests.

Learning styles	Teaching styles	N	Pre-test mean[(a)]/S.D.	Post-test mean[(b)]/S.D.	Mean difference (a)−(b)/S.D.
Reflective	Brainstorming	10	1.70/0.68	2.60/0.84	0.90/0.74
	Instruction and recall	9	1.22/0.44	3.11/0.93	1.89/1.17
Active	Brainstorming	10	2.10/0.57	4.00/0.82	1.90/0.88
	Instruction and recall	10	2.60/1.27	3.50/1.18	0.90/1.37

[a] Match Group: The students who received the matched teaching style. That is, the group of students with reflective style received the "instruction and recall" teaching style. Those who are characterized as having an active learning style received the "brainstorming" teaching style.

[b] Mismatch Group: The students who received the mismatched teaching style. That is, the group of students with reflective style received the "brainstorming" teaching style. Those who are characterized as having an active learning style received the "instruction and recall" teaching style.

questions. Hence, King suggested that initiating question components with lower-level questions regarding factual knowledge and then gradually moving to higher-level questions of reflection will enhance their comprehension. Redfield and Rousseau (1981) analyzed twenty studies of cognition levels and suggested that if more higher-level questions are given in a class, learners will achieve higher learning performance. Chen, Wei et al. (2008) and Lee and Chen (2009) also suggested that positing higher-level questions that encourage reflection leads to deeper understanding. This study used higher-level questions to help students examine their understanding, correct misconceptions, and elaborate the knowledge and experience they obtained from the learning activity (Roscoe & Chi, 2008).

2.3. Ubiquitous learning

The rapid development of mobile technology and wireless networking technology has given rise to the emergence of u-learning environments. A ubiquitous learning environment is a pervasive and persistent setting allowing students to access learning materials flexibly and seamlessly, in any location at any time, both from the physical environment and from the Internet (Hwang, Tsai et al., 2008; Jones & Jo, 2004; Ogata & Yano, 2004; Waller, 2009). Students are self-directed in a u-learning environment. When they are situated in a u-learning environment, they can utilize information afforded both by the real world and the Internet to solve problems in a timely manner (Chiou, Tseng, Hwang, & Heller, 2010; Hartson, 2003; Waller, 2009). In addition, students can also interact with experts, instructors, or learning peers. All students' learning activities can be recorded for later review and evaluation. The u-learning environment can thus host learning activities which are student-centered, knowledge-centered, assessment-centered, and community-centered (Bransford, Brown, & Cocking, 2000; Hwang, Shi, & Chu, 2010).

Many formal and informal learning activities have been implemented in a u-learning environment. For instance, El-Bishouty, Ogata, and Yano (2007) created a u-learning environment to support learners' sharing of knowledge, peer interaction, collaboration, and exchange of experience while learning computer hardware maintenance. In their study, students obtained ambient resources from a handheld device and thus were able to access the pertinent information for solving problems. Hwang, Yang et al. (2009) instructed inexperienced learners to practice single-crystal X-ray diffraction operations. In their experiment, the design of their u-learning system helped the learners find the required resources and instructions. Also, Chu, Hwang, Huang et al. (2008) developed a u-learning environment to assist elementary students to observe and distinguish butterfly features in a science course. Liaw, Hatala, and Huang (2010) developed learners' knowledge management system with PDA to enhance learners' satisfaction and encourage learners' autonomy. Liu and Chu (2010) used ubiquitous games in an English listening and speaking course. Huang et al. (2010) developed a mobile plant learning system to facilitate student learning in an elementary-school-level botany course. These examples demonstrate the capability as well as the potential of u-learning environments in supporting various types of learning activities.

3. Method

3.1. The participants

The experiment was conducted at an elementary school in southern Taiwan. Two classes comprised of a total of 39 fifth graders and taught by the same teachers participated in this study. The students were involved in a PDA-based study of butterfly ecology. The students were 11 years old on average. For the sake of convenience, the authors of this study deliberately assigned one class of 20 students to a group that utilized a brainstorming teaching style and the other 19 students to a group that emphasized an instruction and recall teaching style. Each student was given a PDA to use for information retrieval, communication and recording observations.

3.2. Measuring tools

Pre- and post-tests were designed to evaluate the students' reflection levels. The pre-test contained one question that asked students about how to build a butterfly habitat in accordance with their preliminary understanding of butterfly ecology. Similar to the pre-test, the

Table 4
Two-way ANCOVA on students' learning gain.

Source	SS	df	MS	F
Learning styles	0.26	1	0.26	0.23
Teaching styles	0.06	1	0.06	0.06
Teaching styles × Learning styles	8.63	1	8.63	7.81**

$^{**}p < 0.01$.

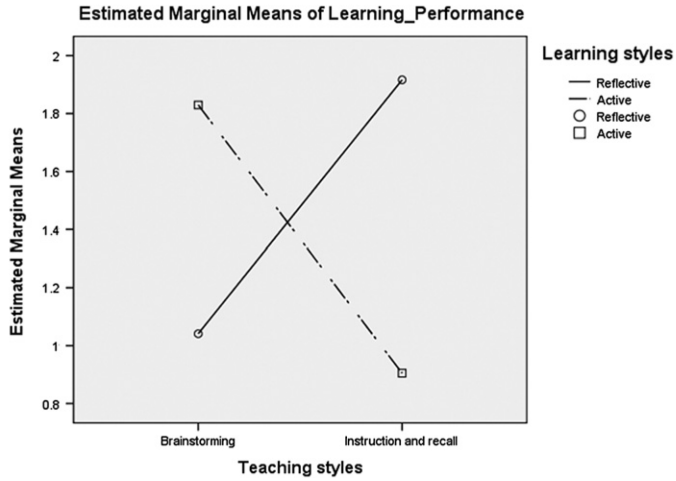

Fig. 2. Means plot of learning performance for the interaction between teaching styles and learning styles.

post-test contained one question asking students about how to build a habitat specifically for *Idea leuconoe clara* based on what they had just learned in the designed activities. The reflection scale developed by Bain, Ballantyne, Packer, and Mills (1999), as shown in Table 1, was used to evaluate the students' responses to the pre- and post-test questions. Two trained research members evaluated the students' answers on both the pre- and post-tests. The inter-rater reliability of the pre-test was 0.97 and that of the post-test was 0.99.

The Index of Learning Styles (ILS) developed by Felder and Soloman (1997) was used to identify students' learning styles in the dimension of processing information. There are 11 questions in ILS that determine if one's learning style is active or reflective. In each question, there are two options that indicate a preference for an active or reflective learning style. Students chose one preference from the two options. One is classified as an active learner if the number of active options chosen is more than that the number of reflective options; conversely, one is classified as a reflective learner if the number of reflective options chosen is more than that the number of active options. The grouping of students is presented in Table 2.

3.3. Experiment design

The experiment consisted of three stages. In the first stage, the students received a prior knowledge test of butterfly ecology, a pre-test that evaluated their reflection levels, and the ILS questionnaire. In the second stage, they used PDAs to observe butterfly ecology in the butterfly garden. Information regarding the four stages of the butterfly life cycle (egg, larva, pupa and adult) was wirelessly sent to the students' PDAs. In the butterfly garden, the students followed the instructions shown on their PDAs and observed the characteristics of the butterfly's life cycle, as shown in Fig. 1.

Following the observation session, the students started a reflection session. A question that asked how to breed *Idea leuconoe clara* was given. The students were given 15 min to discuss the question as a group. For students involved in the group of instruction and recall, five prompts were given via their PDAs every 2 min. They were given 5 min at the end to summarize their own answer.

In the last stage, the students were given a post-test that measured their reflection levels. They were asked about designing a habitat specifically for *Idea leuconoe clara* based on what they had just learned from the observation session. Their answers were evaluated according to the grading criteria shown in Table 1.

3.4. Data analysis

The participated students received a prior knowledge test about butterfly ecology, a pre- and post-test to evaluate their reflection levels, and the ILS questionnaire was conducted to assess their learning styles. The grades of prior knowledge test from the two groups' students were analyzed by a Mann–Whitney U test to verify if the prior knowledge of the two group students were significantly different. And, this study used students' prior knowledge as the covariate to neutralize the effect of prior knowledge about butterfly ecology. Learning styles and teaching styles as the independent variables, and mean difference between the pre- and post-tests as the dependent variable to conduct a two-way ANCOVA to explore the effects of teaching and learning styles on students' reflection levels.

Table 5
Summary of simple main effect analysis for learning gain.

Source	N	Mean of learning gain	S. D. of learning gain	F-value	Post-hoc
Teaching Styles					
Reflective	19	1.37	1.07	4.99*	Instruction and recall > Brainstorming
Active	20	1.40	1.23	3.78	n. s.
Learning Styles					
Brainstorming	20	1.40	0.94	7.63*	Active > Reflective
Instruction and recall	19	1.37	1.34	2.83	n. s.

*$p < 0.05$.

Table 6
Descriptive data and ANCOVA of the learning gain results.

Group	N	Pre-test mean[(a)]/S.D.	Post-test mean[(b)]/S.D.	Mean difference (a)−(b)/S.D.	F-value
Match[a]	19	1.70/0.68	2.60/0.84	1.89/0.99	8.32**
Mismatch[b]	20	1.22/0.44	3.11/0.93	0.90/1.07	

$^{**}p < 0.01$.
[a] Match Group: The students who received the matched teaching style. That is, the group of students with reflective style received the "instruction and recall" teaching style. Those who are characterized as having an active learning style received the "brainstorming" teaching style.
[b] Mismatch Group: The students who received the mismatched teaching style. That is, the group of students with reflective style received the "brainstorming" teaching style. Those who are characterized as having an active learning style received the "instruction and recall" teaching style.

4. Results and discussions

4.1. The effect of prior knowledge

As mentioned before, this paper deliberately assigned one class of 20 students to a group that utilized a brainstorming teaching style and the other 19 students to a group that emphasized an instruction and recall teaching style. In order to examine if their prior knowledge of butterfly ecology was significantly different, a self developed question was adopted as a prior knowledge test. The prior knowledge test grades of the two classes were analyzed by a Mann–Whitney U test to determine if the classes had significantly different prior knowledge of butterfly ecology. The result shows that their prior knowledge was not significantly different (p-value $= 0.398$). This study also used a Kolmogorov–Smirnov Z test to determine if a t-test could be used in a prior knowledge test, with the result showing that the data met the assumption of normality. Finally, a t-test was used to examine if their prior knowledge of butterfly ecology was significantly different. The result shows no significant difference between the test scores of the two groups ($t = -0.742$, p-value $= 0.463$); that is, the two groups of students had equivalent knowledge concerning butterfly ecology before participating in the learning activity.

4.2. Learning gain of reflection level on the pre- and post-tests

The descriptive statistics of the students' reflection levels on the pre- and post-test are shown in Table 3. This study discusses how, if at all, the variables of different teaching styles offered in a u-learning context and the variables of students' learning styles affect learning gain, which is the mean difference between the pre- and post-tests. Hence, we used students' prior knowledge as the covariate to neutralize the effect of prior knowledge of butterfly ecology, learning styles and teaching styles as independent variables, and learning gain as the dependent variable to perform the two-way ANCOVA as shown in Table 4.

The results shown in Table 4 illustrate that both the main effects of individual learning styles ($F = 0.23$, p-value $= 0.63$) and teaching styles ($F = 0.06$, p-value $= 0.82$) are not statistically significant. This means that learners with different learning styles or teaching styles did not in themselves produce a significant difference within learning gain. However, the effect of the interaction between individual learning styles and teaching styles was significant ($F = 7.81$, p-value $= 0.01$). The interaction effects could also be found at the estimated marginal means plot in Fig. 2. These results show that the teaching styles and learning styles had an interactive effect on learning gain.

A statistical interaction occurs when the effect of one independent variable (teaching styles) on the dependent variable (learning gain) changes depending on the level of another independent variable (learning styles). In our current design, this is equivalent to asking whether the effect of teacher styles changes depending on the learning styles of the student. To determine if this is the case, we need to look at the simple main effects (Weinberg & Abramowitz, 2002). Simple main effects are the effects of one factor at the level of the other factor. Conducting analyses of simple main effects permits you to make sense of the interaction.

In order to further understand the interactive effect between teaching styles and learning styles, this study uses simple main effect as the post-hoc analysis, as shown in Table 5. For reflective style, the simple main effect of teaching styles was significantly different ($F = 4.99$, $p = 0.04$). This implies that when learners' learning style is reflective, their learning gain with the instruction and recall style (Mean $= 1.89$) is higher than with the brainstorming style (Mean $= 0.90$). In addition, for the brainstorming style, the simple main effect of learning styles was significantly different ($F = 7.63$, $p = 0.01$). This reveals that when the teaching style is brainstorming, the learning gain of active learners (Mean $= 1.90$) is higher than that of reflective learners (Mean $= 0.90$).

These results are similar to the findings of Felder and Silverman (1988). Based on Felder and Silverman's (1988) suggestions regarding the matching of teaching and learning styles, the combination of teaching and learning styles was classified into matched/mismatched groups. Students who were in the *matched* group were active learners who were taught using a "brainstorming" style and reflective learners who were taught using an "instruction and recall" style. Students assigned to the *mismatched* group were active learners who were taught using an "instruction and recall" style and reflective learners who were taught using a "brainstorming" style, as shown in Table 6.

The students' learning gain was compared in terms of the matched/mismatched combination of teaching styles and learning styles. A one-way ANCOVA was used to test the matched/mismatched factor with students' prior knowledge as a covariate. The result suggested that those students involved in the matched groups had significantly better learning gain than those in the mismatched groups ($F = 8.315$, $p = 0.01$). That is, matching the learning styles of students with the associated teaching styles will significantly improve the students' reflection levels within a u-learning context.

5. Conclusion and recommendations

The features of u-learning environments create a flexible and fertile context that can accommodate various learning activities. In this study, two classes of students studied butterfly ecology using PDAs in a u-learning environment. Following an observation session, the students were instructed to reflect on what they had just learned. This study considered two factors that might influence the students' reflection, including the instructor's teaching style ("brainstorming" or "instruction and recall") and the students' learning style (active or reflective). Taking the students' prior domain knowledge into account, it was found that their prior knowledge had a significantly positive relation with the pre-test, post-test and learning styles. Therefore, students' prior knowledge was used as a covariate in subsequent analyses.

It was found that students whose learning styles were matched with the corresponding teaching style showed significantly greater improvement in reflection than those in the mismatched group. This result supports the findings reported in other studies (e.g., Brusilovsky & Maybury, 2002; Felder & Silverman, 1988; Kinshuk et al., 2009; Manouselis & Sampson, 2002; Masthoff, 2002; Melis et al., 2001) that an instruction method adapted to students' learning style enhances learning and improves learning performance. Instructors are thus encouraged to probe students' learning styles and develop teaching strategies that correspond to the students' needs. Using a teaching format that specifically conforms to a given learning style can substantially increase the quality and quantity of a student's knowledge acquisition. In addition, a crucial element of teaching is the post-instruction provision of questions that elicit reflection. A period of reflection offers the student an opportunity to reinterpret information and cement new knowledge.

The future study of this research includes increasing the sample size to increase the power of the found effects. In addition, many studies are explicit in demonstrating that numerous factors affect learning, such as IQ, gender, and personal characteristics. The exploration of learning and teaching in u-learning environments should also take these factors into consideration in a holistic way to make learning as well as reflection an enjoyable and more productive experience.

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