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Learning Behavior Analysis of a Ubiquitous Situated Reflective Learning System with Application to Life Science and Technology Teaching

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ABSTRACT

Education research has shown that reflective study can efficiently enhance learning, and the acquisition of knowledge and skills from real-life situations has become a focus of interest for scholars. The knowledge-learning model based on verbal instruction, used in traditional classrooms, does not make use of real-life situations that encourage students to engage in reflective learning. However, by implementing the Ubiquitous Situated Reflective Learning System (USRLS), learners can be provided with real situations, faced in daily life at any time, to encourage them to engage in reflective learning with regard to information pertinent to the class. This study adopted a quasi-experimental design to assess the efficacy of these two learning models. The research subjects were 52 students from two grade 5 classes in one elementary school in the middle part of Taiwan. The USRLS was used for teaching the experimental group, while the traditional oral teaching method was used for the control group. The learning content of fifth-grade life-science technology classes consists of units on burning and rusting in the context of the life sciences and technology. The research results showed that (1) the learning effectiveness of the USRLS is superior to that of the traditional oral teaching model and (2) students in the high-learning achievement (HLA) group are best suited to a text-based self-reflective learning strategy, while students in the low-learning achievement (LLA) group can obtain more help by using a text-based peer-reflective strategy. Students noted that the learning cycle of a situated reflective learning model encouraged them to consider lesson content, helped them review their answers, and enabled them to increase their focus on the concepts and information in the learning task.

Keywords

Situated learning, Reflective thinking, Ubiquitous application

Introduction

Situated learning is a theory of learning that stresses the role of context. According to this approach, learning includes the situational context in which it occurs (Brown, Collins, & Duguid, 1989; Hou, 2011). Indeed, knowledge is embedded in its situational context as well as in the learning activities (Kim & Hannafin, 2011). Situated learning emphasizes the non-official or incidental learning that occurs outside the classroom; it views actions during real interactions as ways to acquire knowledge and capabilities (Zurita, Baloian, & Frez, 2014). Situated learning includes not only the cognitive process of knowledge acquisition but also the learning that occurs during social interactions (Saigal, 2012; Hwang, Chen, Shadiev, Huang, & Chen, 2012). It uses real environments to encourage independent and autonomous thinking as well as to apply active methods to acquire knowledge, thus emphasizing that learning should be based on real-life situations (Arnseth, 2008). Based on learning situations in which different academic subjects are taught, situated learning can include apprenticeships, collaborative learning, multiple opportunities for practice, and the articulation of what has been learned, all of which have been proven to enhance learning achievement (Compton, 2013; Woolf & Quinn, 2009).

Reflection on learning can train students to gather information from their everyday lives and to apply it to solving problems by using their own knowledge to solve life technology-based problems and by relying on scientific evidence to explain the outcomes (Greiff, Holt, & Funke, 2013). Reflection has an important role in the learning process (Hung, Yang, Fang, Hwang, & Chen, 2014; Koong, Yang, Wu, Li, & Tseng, 2014). When learners are able to reflect on the instructional materials provided during the learning process, they are able to gain a better understanding of their effects (Aleven, McLaren, Sewall, & Koedinger, 2009; Chen, Kinshuk, Wei, & Liu, 2011). Studies have shown that learners who encounter real situations while reflecting on their learning show improved learning effects (Kim, 2011; Russell, 2008).

During the implementation stage of the sciences and technology curriculum guidelines, fifth-grade students cultivate their abilities to observe and classify knowledge (Hsu & Kuan, 2013). Verbal instruction employed in traditional classrooms does not provide real-life situations for students to experience and explore. Facilitating elementary school students to engage in thinking activities that involve reflective learning can improve their observation and classification abilities through applying their classroom knowledge. This study proposes a learning strategy based on a situated reflective learning model and system. This system provides learners with time to reflect on and to share the knowledge they gain in their daily lives in response to real-life situations. This study focused on the science and technology curriculum of fifth-grade students; the instructional design was based on the learning cycle of a situated, reflective learning model (Collins, 1994; Zimmerman & Schunk, 1989) to elucidate its educational benefits and to analyze differences in the learning behaviors of high-achieving and low-achieving students. Therefore, the research questions of this study are as follow. (1) The study analysis the learning effectiveness differences for the USRL teaching and traditional oral teaching. (2) The present study explored learning behavioral differences between the HLA group and the LLA group in self-reflective learning and in peer-reflective learning. (3) The study also investigated the correlation between learning achievements and reflective learning behaviors of the HLA group and the LLA group.

Literature review

Situated learning

Many positive research outcomes have been associated with the introduction of situated learning theory, which has been most widely applied in the natural sciences. Onsite observations for purposes of annotation and comparison can help students understand the scientific phenomena described in abstract text (Chu, Hwang, & Tsai, 2010; Tan, Lin, Shu, & Liu, 2012). In learning Chinese, situated learning theory can be used to combine Chinese poetry that is difficult to understand with situations that deepen understanding of the meanings of the poetry (Chen & Lin, 2016; Shih, Tseng, Yang, Lin, & Liang, 2012). In learning mathematics, Shih, Kuo, and Liu (2012) used a learning method involving a mathematics path to connect related mathematical concepts with objects in daily life to help learners understand abstract concepts. These studies have consistently shown that using real situations to elucidate knowledge that is otherwise difficult to understand can achieve positive learning effects. Hwang, Shi, and Chu (2011) believed that if there is no appropriate learning strategy or tool to help learners with situated learning, the learning effects are usually disappointing, despite the use of novel learning strategies that combine new situations with E-learning.

The instructional strategies used in situated learning approaches help students learn by observing and participating in real situations and emphasize that learning involves active interactions between learners and the environment that integrate previous experiences in the service of learning new knowledge or developing problem-solving strategies. Collins (1994) proposed that situated learning strategies involve six characteristics as follows: (1) Authentic context: all knowledge and skills must be learned in real situations to help students immediately apply the knowledge they learned to their lives. (2) Coaching: intersperse learning between the completion of learning tasks to develop familiarity with specific knowledge or skills so that students learn to solve specific problems at the same time as they learn to apply knowledge in different situations. (3) Articulation: guide students to engage in deeper thinking about knowledge they have learned so they can generalize it to other situations. (4) Reflection: guide learners to engage in reflecting on whether what they have learned is accurate and to think about whether there are other solutions. (5) Circulation: provide consistent opportunities for learning so that learners can continuously practice learning similar material and improve their problem-solving abilities, leading to a sense of accomplishment with regard to the process of solving problems. (6) Multiple media: use different types of media to demonstrate different learning characteristics so that the context of instruction more closely resembles actual contexts, which enhances the effects of learning.

Reflective learning

Reflective ability has been seen as a learning strategy and means to elevate learning benefits (Hsu, 2011). Reflection can be used to evaluate learning accomplishment experiences and promote the elevation of learning motivation (Mansvelder-Longayroux, Beijaard, & Verloop, 2007). Barrett (2008) pointed out that learning systems with the e-portfolios function, and design and completeness of reflection mechanisms would affect the reflective techniques and thinking of learners. Recently, many studies on the reflective learning issue have explored the effect of reflection on professional knowledge learning in university students, finding that reflection is positive for learning, and promoting and encouraging students to undertake reflective learning (Bhattacharya & Chauhan, 2010; Koong et al., 2014; Van de Boom, paas, & Van Merriënboer, 2007).

Common literature on specific exploration of reflective learning structures includes self-reflection in the self-regulated learning theory by Zimmerman and Schunk (1989) and continuum of levels of reflection proposed by Grossman (2008). In the self-regulated learning theory, self-reflection can be divided into four cycling stages. In the self-evaluation stage, learners focus on their own learning performance to compare them with those of others, and evaluate the reflection of their mistakes. In the attributions stage, learners reflect on their mistakes and think about the reasons. In the self-reaction stage, learners derive different self-reflection due to different attribution conclusions, if learners acquire positive self-reactions, learners would consider feasible solutions, and effectively improve upon the incorrect concepts. In the adaptive stage, the attributions stage affects the outcomes of the self-reaction stage. It promotes learners' discovery and confirmation of learning mistakes, so that they take action to adjust the learning actions of learners.

Previous literature related to situated and reflective learning have discussed differences in learning effectiveness for students with higher and lower achievement. For instance, Lin (2014) showed that the progress of students with lower achievement in geometry was superior to those with higher achievement, with the assistance of peers, which is of particular help in facilitating our knowledge of learning achievement based on measurement and estimating ability. According to Chen and Lin (2016), their situated learning game system in Chinese poetry focused on poetry of the Tang Dynasty, where the difficulties encountered by poets during the writing process are simulated into animation. Moreover, the multimedia annotation e-book learning system, to facilitate English language learning, can provide personalized learning, whereby annotations are made regarding more complex concepts to assist in follow-up study at home. Additionally, there is an annotation-sharing feature so that low and high achievement students can see each other's comments, which contributes to the learning progress. It has been documented that high achievement students engage in annotation sharing significantly more than their low achievement counterparts (Hwang, Liu, Chen, Huang, & Li, 2015).

Ubiquitous situated reflective learning

Situated reflective learning model

The situated reflective learning model was divided into two phases: the situated reaction and the reflective reaction. The situated reaction was based on the situated instructional strategy recommendations offered by Collins (1994), whereas the reflective reaction was based on the integration of the self-reflective steps outlined in the self-regulated learning theory developed by Zimmerman and Schunk (1989), as shown in Figure 1. This model was divided into five steps. The first step is articulation, in which classroom teachers lead students in making judgments and classifications, enabling them to think more deeply, thereby facilitating knowledge transfer. The second step is authentication, which involves the use of articulation to derive knowledge and skills from real-life environments; in this step, students learn to observe and record their thinking processes as they acquire knowledge. The third step is evaluation, which focuses on the knowledge acquired in the authentication step via reflection on the accuracy of the knowledge gained; it enables students to evaluate the correctness of their thinking or responses. Students discuss and share ideas with classmates to facilitate the process of evaluating knowledge acquisition. The fourth step is planning, which uses the evaluation and reflection from the previous steps to consider whether knowledge had been misclassified or if the concepts are incorrect; students are encouraged to consider which real-life scenarios match these concepts and to re-evaluate their plans. The fifth step is adaptation, which confirms the reasons for erroneous learning and leads to adjustments in learners' behavior. In other words, the plan from the previous step is converted into real action, which, in turn, increases students' awareness of the knowledge they have acquired.

The implementation steps of the situated reflective learning model were based on the teaching process of Taiwan's elementary schools. One reflective cycle process was conducted according to the connection generated by elementary school students between life situation topics and knowledge learned in the classroom. This model adopted the advantages of the situated learning theory proposed by Collin (1994) and the self-regulated learning theory proposed by Zimmerman and Schunk (1989) and simplified them into five steps. Situated learning theory emphasizes the link between the real-life environment and knowledge learned in class, as well as the ability development of its immediate use, but there are no detailed steps or implementation models in the narrative of reflective learning, so the steps of self-regulated learning theory were added to establish a complete situated reflective learning model. In self-regulated learning theory, it is thought that the reflective learning process requires specific practice to make the learning adjustment. Many scholars believe that a reflective learning process requires definitive ways to adjust learning (Dabbagh & Kitsantas, 2012; Koong et al., 2014; Littlejohn, Milligan & Margaryan, 2012; Montgomery, 1993). Therefore, step four of the five steps was a plan to evaluate classification errors or concept errors and redraft a plan to carry out correct learning. Such a model can be fully integrated with the teaching of elementary school courses.

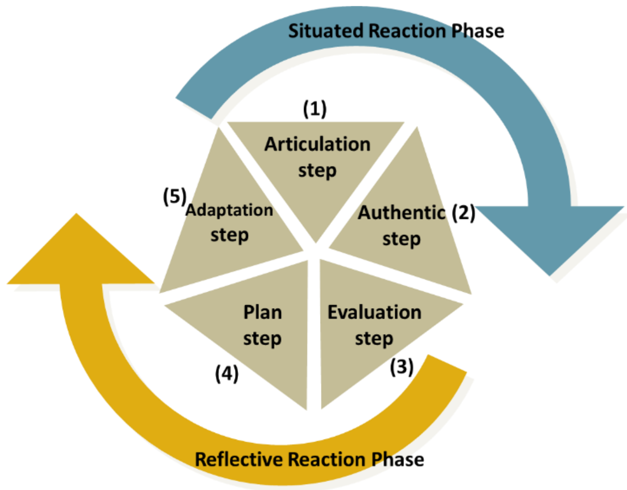

Figure 1. The five steps of situated reflective learning model

Design of ubiquitous situated reflective learning system

The ubiquitous situated reflective learning system was developed based on the above proposed situated reflective learning model, which allows for reflective learning about life context and classroom knowledge at any time and place through mobile devices. This system includes an E-book for the course, teacher lectures, annotations, reflective learning, and instructional activities. For the function of E-book for the course, this system consists of an E-book for the units pertaining to fire and rust in the life technology class as shown in Figure 2.

Figure 2. Ebook for the course

For the function of teacher lecture, students can use the lecture function to record the lecture for review at home as shown in Figure 3. For the learning annotation, students can annotate their class notes in the E-book in the learning process. This includes not only text annotations but also vocal comments and photographs. Annotations can be saved or deleted as shown in Figure 4. For the reflective learning, students can use the system to browse the learning content drawn from the life contexts of other classmates and engage in online discussions about and validation of answers, as shown in Figure 5. For learning activities, these are matched to the curricular instruction so that students can engage in reflective learning through connections with their life contexts.

In the step of establishing a new object, the system uses the GPS positioning function to search for the current location of the student to record data for the experiment, as shown in Figure 6. In the step of taking photographs, after students input and identify the names of objects, they select photographs of them, and the system again confirms whether the object name is correct. If they choose “confirm,” the camera function starts, and students point to the center of the screen at the new object to take a photograph of the object. If the photograph is blurry or distorted, they can retake it, as shown in Figure 7. In the step of description and recording, students can choose whether to input text or a recorded verbal description regarding why the photo conforms to the knowledge learned in the course. When they finish the explanation, they press “complete” to send it, as shown in Figure 8.

Figure 4. Learning annotation

Figure 5. Reflective learning

Figure 6. Establishing a new object

Figure 7. Taking photographs

Figure 8. Description and recording

In terms of USRLS instructional activity functions, the steps in the situated reflective learning model assist reflective learning in relation to real-life situations, as shown in Table 1.

Table 1. Situated reflection learning model and USRLS supporting functions

Step	Purpose description	USRLS supporting functions
Articulation step	Learners thinks about learning, then judges and classifies	Teachers with explanatory function
Authentic step	Discover connections in knowledge from real-life situations	Learning annotation functions, gps situated trigger function, photography function, and sound recording function
Evaluation step	Learners can reflect on the correctness of knowledge and discuss with other students	Learning annotation function, reflective learning function, photography function, and sound recording function
Plan step	Reflection processes to confirm errors in concepts, and reestablish the plan to implement learning of correct knowledge.	Learning annotation function and reflective learning function
Adaptation step	To confirm the reason for incorrect learning, to covert plans to actual action	Learning annotation function and reflective learning function

Method

Participants and learning material

The sample consisted of 52 students in two fifth-grade classes at an elementary school in central Taiwan. One class of 25 students formed the experimental group and another class of 27 students formed the control group. Students had access to information technology tools, including word processing, presentations, and tablet computers. The instructional material consisted of units on the topics of fire and rust, which were part of the life technology course. In the fire unit, students learned about the classification of fires, such as fires caused by flammable solids, liquids or gases, and electrical equipment. In the rust unit, students learned about different types of rust, including the rusting properties of iron, aluminum, and copper. The fire and iron are selected as the learning unit because in reality they are commonly seen even to the elementary school students in daily life. It can be used to conduct the situated reflective learning activity. The elementary school students in experimental group and control group come from the same elementary school, have the same background knowledge and also share the same teacher in the course of life science and technology.

Research design

This study adopted a quasi-experimental design. The control group received traditional oral instruction, whereas the experimental group received instruction using the ubiquitously situated, reflective learning system (USRLS). Figure 9 shows the research framework diagram. The independent variable was that of the different instructional methods. The experiment group used the USRLS instructional method, while the control group received traditional oral instruction. The control variables included instruction by the same teacher, the same instructional times, the same instructional progress, the same content, and the same test methods. The covariate variable was the learning achievement pre-test score. The moderator variable was the level of learning achievement. HLA group and LLA group are distinguished by students' academic performance in the previous semester. The top 50% students are selected as HLA group while the last 50% students are selected as LLA group. Such analysis method with different learning ability has been adopted by many literatures (Chen & Lin, 2016; Lin, 2014).

The dependent variables were learning achievement post-test scores, the number of self-reflective learning instances, and the number of peer-reflective learning instances. To ensure the reliability of the experimental outcomes, the two groups were both taught by the same teacher during the 4-week instruction period, and both groups followed the same instructional schedule. The first 2 weeks of the life technology course covered the fire unit, and this was followed by the rust unit in the second 2 weeks. The control group received traditional oral instruction from the teacher to enable them to engage in reflection regarding the curricular content, whereas the experimental group used the USRLS to participate in context-reflective instructional activities based on the same content. The five steps in the situated reflective learning activity belong to the situated reflective learning model proposed, so that students can reflect on the knowledge seen in the daily life situations and learned in the classroom and transform the incorrect concept into the correct knowledge. This activity cooperates with the teaching progress in elementary school and a total of 4 weeks of learning time is planned in the theme learning of fire and iron. For example, students were asked to connect what they had learned with what they had experienced in life, to reflect on the causes of fires, and to record and photograph them; they were also encouraged to discuss their ideas with their classmates to confirm their answers. One question, for example, concerned the type of fire frequently caused by faulty electrical equipment. This learning system encouraged students to discuss, evaluate, and reflect on the content with their classmates to determine whether they had made erroneous classifications of, and thought processes about, electrical equipment. In the unit about rust, students were asked to connect with, and reflect on, experiences in their daily lives to help them to classify the rust found on metal products they encounter regularly as shown in Figure 10.

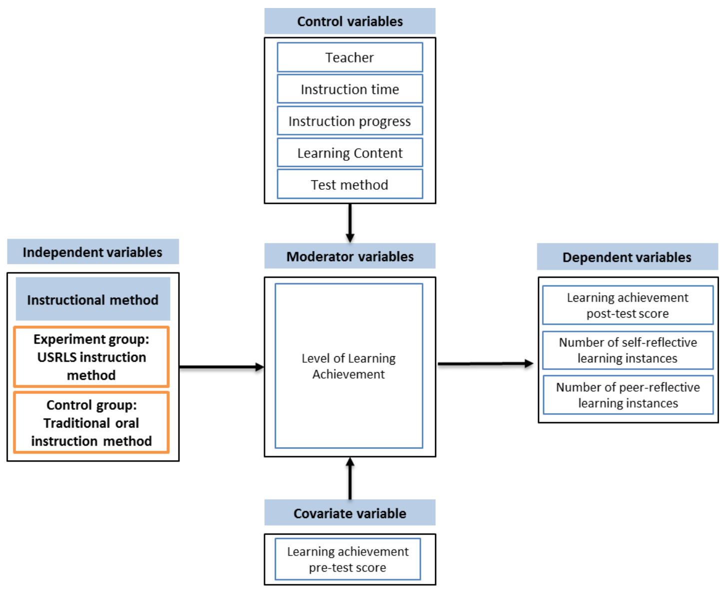

Figure 9. Research framework diagram

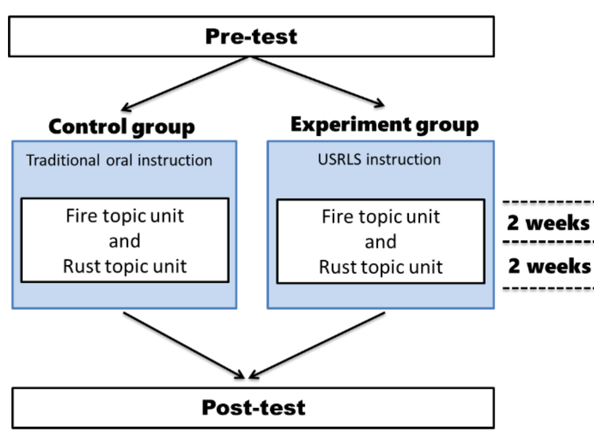

Figure 10. Learning activities for control group and experiment group

The control group received traditional oral instruction. The situated reflective learning model was employed for the experimental group, and records on paper were used to implement the five steps (listed below). Iron rust was used simply for explanation.

Step 1: Able to check the textbook and use knowledge taught by the teacher to evaluate and classify knowledge on iron rust.

Step 2: Able to connect learned knowledge with life contexts, identify which objects will rust, and write down explanations for the objects.

Step 3: Able to think about the casing of fire alarms commonly seen in daily life and what materials they are made from that may rust. When students next return to the classroom, they take out their reflective learning sheet to help them carry out discussion with students in their group, and they evaluate and reflect on whether their classifications and ideas about fire alarm casings are correct.

Step 4: If they are wrong, students set out to reconsider which other objects also rust, look for them in their daily life contexts, and record them on their reflective learning sheets.

Step 5: Able to review the textbook and knowledge taught by the teacher on iron rust to confirm the reason for any incorrect learning and thereby improve the accuracy of their knowledge.

Instrument of assessing students' reflective level

Learners who engage in reflection, based on the knowledge they have learned, show better memory and understanding. Based on the reflective content of learners, Bain (1999) proposed the following five-level criteria for the evaluation of reflection: reporting, responding, relating, reasoning, and reconstructing. Reporting refers to merely repeating existing content. Responding refers to using only a few concepts or explaining only phenomenological facts, rather than causes, and describing only personal thoughts. Relating refers to describing the relationships in the text and explaining the reasons behind them. Reasoning refers to an in-depth explanation of reasons for a phenomenon and discussion of the relationships between theory and practice. Reconstructing refers to the ability to describe a high-level reasoning and reconstruction process in the context of both personal experiences and more general rules in a way that demonstrates a systematic understanding of the theory and a process by which conclusions are reached. Chen, Wei, Wu, and Uden (2009) believed that some learners' reflective content is too simple, incomplete, or incorrect with regard to an understanding of a pertinent problem. However, their original schema did not include an appropriately low level into which such content could be classified. Therefore, the following three reflective levels were added: "nonsense," "too simple," and "incomplete description." This study used the evaluation criteria for reflection proposed by Chen, Wei, Wu, and Uden (2009) to analyze the level of reflection demonstrated by learners regarding the life science technology course.

Results

Analysis of learning achievement

This section addresses the influence of different teaching methods on learning achievements and aims to assess differences in achievement associated with the USRLS teaching approach versus traditional lecturing. The results of a one-way analysis of covariance (ANCOVA) with regard to within-group homogeneity are presented in Table 2. The F value is 0.171, and the p-value is .681. It did not reach the level of significance. The slopes of the regression lines for the two groups can be regarded as the same. Table 3 shows that after the effect of a covariate was eliminated, the F-value was 87.512 and the p-value was .000, which reflect statistical significance at the level of .05 and indicate a significant difference between the learning outcomes associated with the USRLS teaching approach and traditional lecturing. Table 4 shows that, after adjustment, the average score of the experimental group on the learning achievement test was 82.462, which was higher than the adjusted average of control group, 76.017. Thus, the effectiveness of the USRLS approach to teaching fifth-grade science and technology classes was superior to that of traditional lecturing.

Table 2. The test of homogeneity of within-group regression coefficient

Source	Sum of squares	*df*	Mean square	*F*	*Sig.*
Within-group × covariate	7.203	1	7.203	0.171	.681
Error	2016.520	48	42.011		

Table 3. Summary of covariance analysis of the posttest results

Source	Sum of squares	*df*	Mean square	*F*	*Sig.*
Contrast	3614.289	1	3614.289	87.512	.000
Error	2023.723	49	41.300		

Table 4. Adjusted Means for different instructional methods

Source	Pretest mean	Posttest mean	Adjusted mean
Experiment Group	83.24	82.56	82.462[a]
Control Group	83.04	75.93	76.017[a]

Note. [a] = Covariates appearing in the model are evaluated at the following values: pretest = 83.13.

Analysis of the self-reflective learning behavior of HLA and LLA students

This section addresses differences between the quality of text-based self-reflection (QTSR) and that of quality of voice-based self-reflection (QVSR) in high-level-achievement (HLA) and low-level-achievement (LLA) students who were taught using the USRLS teaching approach. According to the results of the independent-sample t-tests, presented in Table 5, HLA students scored significantly higher than did LLA students ($p < .001$) with regard to the QTSR. This result shows that HLA students used the situated reflective model provided by the system more effectively than did the LLA learners with regard to improving their knowledge and providing correct answers. However, we found no significant difference between HLA and LLA students with regard to the QVSR ($p = .471$). This may be due to class rules and teacher preferences that favor students' vocalizing of self-reflections. It may also be due to the fact that there is too much noise in real-life situations, which renders learners unable to use the VSR in real time. Figure 11 shows that the fact is not that the QTSR of HLA learners has gone up after using USRLS teaching, instead, it is that the QTSR of LLA learners has declined gradually as time passes by. This might be due to the fact that LLA learners' feeling of freshness about USRLS system in the beginning of the experiment. However, as this feeling of freshness fades away, low achievement learners' QTSR declines as well.

Table 5. Independent-sample *t*-test analysis for self-reflective learning behavior

	Learning achievement	*N*	Mean	*SD*	*t*	Sig.
Quantity of text-based self-reflection	High	12	5.24	0.67	9.934	$.000^{***}$
	Low	12	2.57	0.64		
Quantity of voice-based peer-reflection	High	12	2.74	0.62	0.733	.471
	Low	12	2.52	0.86		

Note. $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

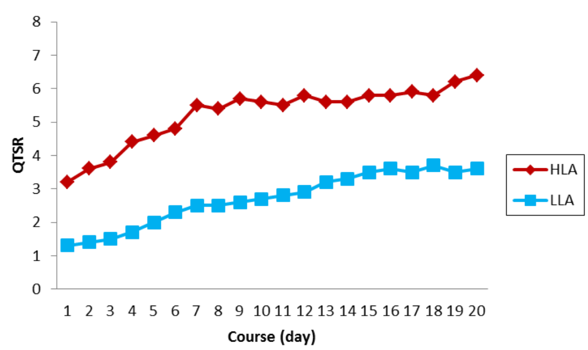

Figure 11. QTSR for HLA and LLA

Analysis of the peer-reflective learning behavior of HLA and LLA Students

This section discusses differences in the quality of text-based peer-reflection (QTPR) and the quality of voice-based peer-reflection (QVPR) in HLA and LLA students who were exposed to the USRLS teaching approach. We will focus on how learners used the situated reflective learning mode provided by the USRLS system to assess the content presented by other students to improve their own understanding of the material. Table 6 presents the results of the independent-samples t-test, which show that HLA learners performed better than LLA learners in terms of both QTPR ($p < .001$) and QVPR ($p <. 001$). This result indicates that HLA students made better use of the situated reflective learning mode provided by the system. Indeed, Figure 12 shows that the QTRP of LLA students was not as high as that of HLA students, but that the QTPR of LLA students gradually increased as a function of time. This might be because LLA students observed the reflected content of other students (especially that of HLA students) and were able to improve their understanding and make better use of the USRLS system.

Table 6. Independent-sample *t*-test analysis for peer-reflective learning behavior

	Learning achievement	*N*	Mean	*SD*	*t*	Sig
Quantity of text-based peer-reflection	High	12	5.57	0.74	6.473	$.000^{***}$
	Low	12	2.98	1.14		
Quantity of voice-based peer-reflection	High	12	4.37	0.47	4.314	$.001^{**}$
	Low	12	2.78	1.19		

Note. $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

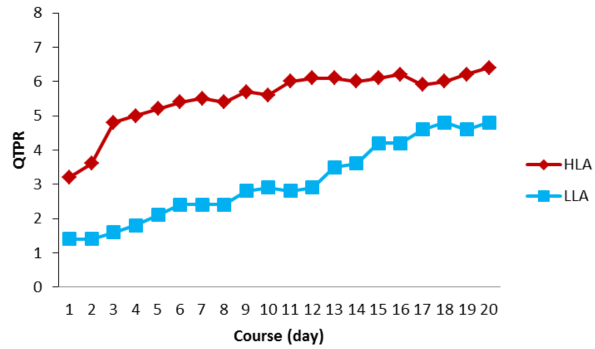

Figure 12. QTPR for HLA and LLA

Correlation between reflective learning behavior and learning achievement

This section discusses the connection between learning achievement and reflective learning behaviors of HLA and LLA learners. Reflective learning behaviors include QTSR, QVSR, QTPR, and QVPR. Table 7 shows that HLA learners are highly correlated to QTSR, while LLA learners are highly correlated to QTPR. This means that good QTSR can be transformed effectively into improvements in learning achievement for HLA students but that QTPR is a crucial factor for knowledge learning among LLA students.

Table 7. Pearson correlation between learning achievement and reflective learning behavior

Learning achievement	QTSR	QVSR	QTPR	QVPR
HLA	$.762^{**}$	.267	$.426^{**}$	$.348^{*}$
LLA	$.323^{*}$	.070	$.757^{**}$	$.117^{*}$

Note. $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

Discussion

The results of Tables 3 and 4 showed that the experimental group, which received the URSLS teaching intervention, performed significantly better than the control group, which received traditional oral teaching. This result confirms previous research suggesting that reflective learning can improve learning. Hung et al. (2014) argued that context-aware reflective learning strategies based on videos can improve learners' levels of reflection and provide real-time individual guidance in the application of reflective learning. Based on evaluations undertaken with vocational education software, Koong et al. (2014) believed that different reflective learning strategies can affect the acquisition of knowledge-based skills.

These data of Tables 5 and 6 show that HLA learners can effectively use the situated reflective learning mode provided by the system to improve their learning achievements. Previous studies on reflective learning did not address the effect of the use of real-life situations to guide students' reflective learning, self-reflective learning behaviors, and peer-reflective learning behaviors on learning achievements. This study found that HLA students performed better using self-reflective learning strategies. With respect to peer-reflective learning behaviors, HLA learners showed greater improvement in their QTPR and QVPR compared with LLA learners. LLA learners spent more time using the USRLS system over time, and their QTPR improved. Additionally, the QTPR of LLA learners was strongly correlated with their learning achievements. It can, therefore, be concluded that LLA students found text-based peer reflective learning strategies particularly helpful. That is to say, students in HLA can understand fact phenomenon, connect personal experience, illustrate and verify the judgment reason for knowledge learned in class. Relatively, students in LLA can only reach incomplete level and reporting level, and they can only repeat the contents without extra ideas, and reflection contents are quite incomplete. The average score of reflective learning behavior in LLA Group is relatively lower from Table 5, showing that the students' reflective learning in LLA Group will not enter responding stage or relating state easily. Under the peer-reflective learning strategies, students' highest reflection level in HLA can reach reasoning level, and they can make a detailed explanation for the reasons why something happens; while students' highest reflection level in LLA can reach responding level, and they can make a brief description for the reasons why something happens.

Conclusions

This study proposes a situated reflective learning model for the implementation of a reflective learning system. This model was applied in a fifth-grade science and technology class to enable students to think about and hone the knowledge they gained based on real-life situations in their daily lives. USRLS can quickly connect classroom knowledge to seen real-life situations for reflection and confirmation, and students can discuss observations in the situation. This situation triggered reflection is an important innovation in the present study. Our data showed that the experimental group, which received the URSLS teaching intervention, performed significantly better than the control group, which received traditional teaching. This study found that the self-reflective learning behaviors varied greatly between HLA students and LLA students using the USRLS. HLA learners performed significantly better than LLA learners with respect to self-reflective learning behaviors. Furthermore, the self-reflective learning behaviors of HLA students were strongly correlated with their learning achievements, whereas their peer-reflective learning behaviors were more weakly correlated with such achievements.

Aimed at the innovative contribution and effect of this paper, the supplementary description is conducted respectively in teaching practical level and academic innovative level. In terms of academic contribution, this paper proposed the situated reflective learning model, which is applied to the ubiquitous real-life situation, so as to strengthen the learners' situated, reflective and self-regulated cyclic learning in face of the real-life situation. Meanwhile, HLA Group and LLA Group were used to analyze the learning behavior in this model, which can be used as the basis and application of follow-up researches related to situated reflective learning. From the perspective of instructional practice, the USRLS can help students use real-world experiences to validate their observations and organization of what they have learned in the classroom and to rethink how their answers differ from or resemble the narratives of other students. The USRLS enables the teacher to understand clearly the needs of each student through the annotations and information shared in reflective learning and to provide further group or individual instruction. Successful development of the USRLS system, which follows the recommendations of Hwang, Shi, and Chu (2011), will be very useful in implementing the ongoing educational reforms set forth in the grades 1–9 curriculum issued by the Taiwan Ministry of Education. This learning style, which involves the use of actual contexts and digital modalities, requires appropriate pedagogical strategies and usually leads to significant improvements in learning performance.

The study implemented the USRLS to provide the real-life situation reflection is currently merely used in the science learning in elementary school, and math can be designed for E-learning materials in the future. Thus, students can learn mathematical concepts from the experience in daily life to cultivate their problem-solving ability in math. In consideration of the current practical teaching status in elementary school in Taiwan, the real-life situations that students can discover seem to be limited, causing the issues shared between students to be overly concentrated. In the future of advanced plans, the USRLS will apply the technology of Augmented Reality to make students understand the thinking in other different situations, so that the discussion between students becomes deeper and more focused. In particular, students can improve their stimulation in learning knowledge and learning motivation, and students' academic achievements can become apparently better in the strategy of cooperative learning.

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