Development of a SoLoMo Game-Based Application for Supporting Local Cultural Learning in Taiwan

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ABSTRACT

Recently, the development of local cultural features and tourism has become important in Taiwan. To support local cultural education, relevant studies have developed outdoor learning approaches and integrated mobile technology to connect real-world and digital-world learning resources. Nevertheless, the above-mentioned developments are usually suitable for a specific learning process and activity. In other words, students may lack the motivation to engage in the same learning process repeatedly after participating in the learning activity. Therefore, to promote students' local cultural learning, this study developed a game-based local cultural learning application based on the social, local, and mobile (SoLoMo) principle. To investigate the effect of the proposed approach on students' learning performance with regard to local culture, a quasi-experiment was conducted on a society course at a Taiwanese elementary school. The experimental-group students learned with the proposed approach, while the control-group students learned with the conventional mobile learning approach. The experimental results showed that, compared with the conventional mobile learning approach, the proposed approach significantly improved the students' learning achievement, learning retention, and learning motivation. Moreover, it was also found that most students showed positive perceptions toward the usage of the proposed application.

Keywords

Local cultural learning, Digital game-based learning, Mobile learning, Social local mobile

Introduction

Recently, the development of local cultural features and tourism has become important in Taiwan. Taiwan's government has also started to facilitate local cultural education and required mandatory education to develop local culture courses for fostering students' cultural-historical perceptions and interests.

In the early stages of course development, traditional classroom instruction with textbooks has been a major pedagogy adopted by teachers in the course (Relan & Gillani, 1997). With the advancement and prevalence of information and Internet technology, relevant paper-based resources have been widely digitalized for local cultural education, and students can thus learn the knowledge without the constraints of time and place. Nevertheless, the literature indicates that it is insufficient to support student learning using only digital learning resources because these resources usually lack appropriate learning contexts (Huang, Lin, & Cheng, 2010a; Wei, Lin, & Lin, 2016). Therefore, according to situated learning theory, relevant research has developed outdoor learning approaches to support local cultural education and integrated mobile technology to connect real-world and digital-world learning resources (Hwang & Chang, 2011; Sung, Hwang, & Chang, 2016). Moreover, through the use of mobile devices with RFID or QR codes, a context-aware learning environment can be developed to capture students' learning status and provide learning guidance or materials (Chiang, Yang, & Hwang, 2014). However, the abovementioned developments are usually suitable for a specific learning process and activity. In other words, students may lack the motivation to engage in the same learning process repeatedly after participating in the learning activity.

Since the development of computer and multimedia technologies, many technology-enhanced learning approaches have been proposed to improve students' learning motivation (Hung, Hwang, & Huang, 2012; Huang, Yang, Chiang, & Su, 2016; Lu, Chang, Kinshuk, Huang, & Chen, 2014). Among the various technology-enhanced learning approaches, digital game-based learning (DGBL) is an effective educational approach to motivate students to repeatedly rise to the challenge of learning activities (Buckley, Doyle, & Doyle, 2017). The DGBL approach integrates learning strategies, materials, or activities into digital games to develop enjoyable learning environments for teachers and students (Chen & Hwang, 2017). In the past two decades, many educational computer games have been developed to provide a pure digital learning game that did not support real-world interactions (Coller & Scott, 2009; Homer, Plass, Raffaele, Ober, & Ali, 2018; Vasalou, Khaled, Holmes, & Gooch, 2017). In addition, the literature has noted that authentic learning contexts are important to

educate students to reduce knowledge gaps between textbooks and the real world (Wong, Chin, Tan, & Liu, 2010; Zualkernan, 2006). This implies that students possibly lack the ability to apply knowledge to real-world situations while learning without authentic contexts. It is important to integrate the DGBL approach with a mobile learning approach that can connect real-world learning environments with gaming scenarios and motivate students to engage in learning tasks to enhance their learning performance.

As mentioned above, in this study, a mobile, digital, game-based learning application based on social, local, and mobile (SoLoMo) principles is proposed to engage students in real-world learning environments with challenging digital game-based learning tasks to learn local cultural knowledge. In SoLoMo, the word "Local" means the students' and sites' geographic information is involved in the learning processes. Local culture represents historical monuments in the student's hometown. In addition, different from the conventional mobile learning and DGBL approaches, the aim of this study is to develop a mobile digital game using the SoLoMo principle to engage students in game scenarios and motivate them to actively interact with real-world and digital-world learning resources in mobile learning processes. To evaluate the effectiveness of the proposed approach, an experiment was conducted to investigate the following research questions.

- Do the students who learn about local culture with the SoLoMo-based DGBL approach show better learning achievement than those who learn about local culture with the conventional mobile learning approach?
- Do the students who learn about local culture with the SoLoMo-based DGBL approach show better learning motivation than those who learn about local culture with the conventional mobile learning approach?
- Do the students who learn about local culture with the SoLoMo-based DGBL approach show better learning attitude than those who learn about local culture with the conventional mobile learning approach?
- What are the students' perceptions of the proposed application in terms of ease of use and usefulness?

Literature review

Digital game-based learning

Digital game-based learning (DGBL) is an instructional approach that integrates learning materials, activities, or strategies into computer or video games. The major aim of DGBL is to effectively motivate students to actively participate in the learning process (Roussou, 2004). In the past two decades, many educational computer games have been developed to provide pure digital games for primary-level to university-level settings across various subject contents (Sung, Hwang, Lin, & Hong, 2017). Van Eck and Dempsey (2002) developed a computer-based simulation game to enhance students' mathematical skills. Papastergiou (2009) proposed an educational computer game to promote students' learning motivation and performance for learning computer memory concepts. Beserra, Nussbaum, and Grass (2017) proposed a drill-and-practice video game to support multiple-choice assessment and capture students' interest and motivation.

To develop an effective educational computer game, researchers noted the following factors: (1) Competition: Competition with other participants or themselves provides motivation to students to engage and achieve a learning task. The competitive element is generally lacking in traditional learning approaches such as a classroom lecture or discussion (Tsai, 2016); (2) Engagement: During the gaming process, students can freely define and modify their gaming strategies according to the specific goals based on the game rules (Hooshyar et al., 2016); (3) Immediate Rewards: In the game, reward settings encourage students to invest time in continuous learning and return to the game to receive more rewards (Beserra et al., 2017); (4) Immediate Reinforcement and Feedback: In the game, students are more likely to learn mistakes since they receive gaming feedback immediately and learn relevant content for challenging the game again.

Furthermore, based on the principle of situated cognition, scholars have stated that educational computer games have positive effects on student learning performance since the learning takes place within a meaningful context (Van Eck, 2006). To date, by using mobile technologies, the DGBL has demonstrated that it is also suitable to support outdoor learning for conducting situated learning activities in the field. With regard to mobile technologies, GPS, RFID, and QR codes are well-known techniques that can be used to acquire students' geographic information through the use of mobile devices. Therefore, the DGBL with mobile technologies can encourage students to play educational computer games for learning particular knowledge in natural environments. Huizenga, Admiraal, Akkerman, and ten Dam (2009) applied mobile devices with the GPS technique in the field to run a mobile city game to help students learn the historical knowledge of medieval Amsterdam. Chen, Liu, and Hwang (2016) used mobile devices with the QR code technique to implement a context-aware mobile game learning system for assisting students in linking what they have learned in in-field

and classroom activities. Hwang, Wu, Chen, and Tu. (2016) developed an augmented reality-based educational game to help students link learning materials with real-world contexts and improve learning performance.

Social Local Mobile

Social-Local-Mobile (SoLoMo) was coined for business and marketing by John Doerr as the result of the growing popularity of mobile devices and social networks with geolocation techniques (Heinemann & Gaiser, 2014). The SoLoMo principle integrates the user's social media platforms and geographic location with her/his mobile devices. For education, although previous studies have not formally mention the term SoLoMo, several studies have proposed similar teaching and learning approaches to SoLoMo. For instance, Boticki, Baksa, Seow, and Looi (2015) developed a mobile social location-aware learning system to support self-directed and collaborative learning activities. El-Bishouty, Ogata, Rahman, & Yano (2010) proposed a social knowledge awareness map for a computer-supported ubiquitous learning environment that can detect surrounding environmental objects and then dynamically provide a social knowledge awareness map for peer students according to the detected objects. Huang et al. (2010b) built a mobile learning network based on collaborative services to recommend learning partners with the same interests and specialties to learners and further support learner-oriented mobile learning knowledge networks. Therefore, for education, SoLoMo-based learning applications can provide personalized learning content based on the students' physical location and connect their learning status with social media platforms. Next, some theoretical perspectives that indicate why this study is beneficial and conducive to developing learning applications with the SoLoMo principle are briefly described with regard to social, local, and mobile aspects.

Social context

Knowledge construction is not confined to an individual; rather, it is a social process between individuals, groups and organizations. From the viewpoint of the social construction of knowledge, Vygotsky posited that the construction of knowledge in a community occurs via the social interactions of its peers (Vygotsky, 1978). This situation occurs frequently in outdoor learning because students have more opportunities to interact with their peers and the environment. Therefore, previous studies have also indicated that outdoor learning is an active interaction process between learners and their environment (Fåhræus, 2004; Wilde, Harris, Rogers, & Randell, 2003). Students engaging in outdoor learning can go far beyond the direct supervision and direction of instructors in traditional classrooms. The outdoor learning experience can further encourage students to connect with social networks based on friendship, cooperation, and information exchange in a learning context.

Local context

The explosion of mobile technology has elevated the concept of contextual relevance in the educational field. Students now expect learning services to provide contextually relevant learning resources that inform, edutain or resolve (Lin, 2016). In this study, the SoLoMo-based DGBL approach was adopted as an educational methodology to promote outdoor mobile learning. Not only can it engage students in real-world learning contexts, but it also provides location-aware learning content based on their geographic information. To achieve this aim, this study applied tablets as a learning instrument to instructors and students. This kind of learning device has powerful orientation capabilities (GPS, Bluetooth, NFC, 3G/4G, and WiFi) that can easily capture the physical position of the learning device.

Mobile context

Mobile technologies are indispensable for building the SoLoMo-based DGBL approach and are an essential medium for connecting students, instructors, learning resources, and environments. During the learning process, mobile technologies can help instructors and students to overcome the barriers of time or space to improve the delivery of knowledge (Lin & Lin, 2016). Moreover, through mobile technologies, instructors and students can easily and flexibly conduct learning activities and exchange learning information in the field without the traditional requirement of the learning community being in the same place at the same time (Chee, Yahaya, Ibrahim, & Noor Hassan, 2017). Therefore, this study developed an edutainment application as a mobile media to support mobile technologies that can determine a students' location to provide learning content that is located nearby and allow students to share learning statuses on a social networking site.

System development

To promote local cultural learning, this study developed a mobile digital game-based learning application based on the SoLoMo principle. The proposed application was implemented by Android programs and integrated mobile techniques (GPS and QR codes), Taiwanese government open data, and social networks. Therefore, instructors and students applied Android-based mobile devices to use the application and conduct outdoor local cultural learning activities. Moreover, in outdoor learning environments, the application captured the geographic information of the students and real-world learning objects and further provided location-awareness learning services to the students. In addition, the students' learning and gaming achievements could be shared with peers on social networks by using the application.

The proposed application was implemented using the Corona software development kit (SDK), and a database was built using Firebase. Figure 1 shows the architecture of the proposed application. The application was composed of three subsystems: a learning system, a gaming system, and an administrative system.

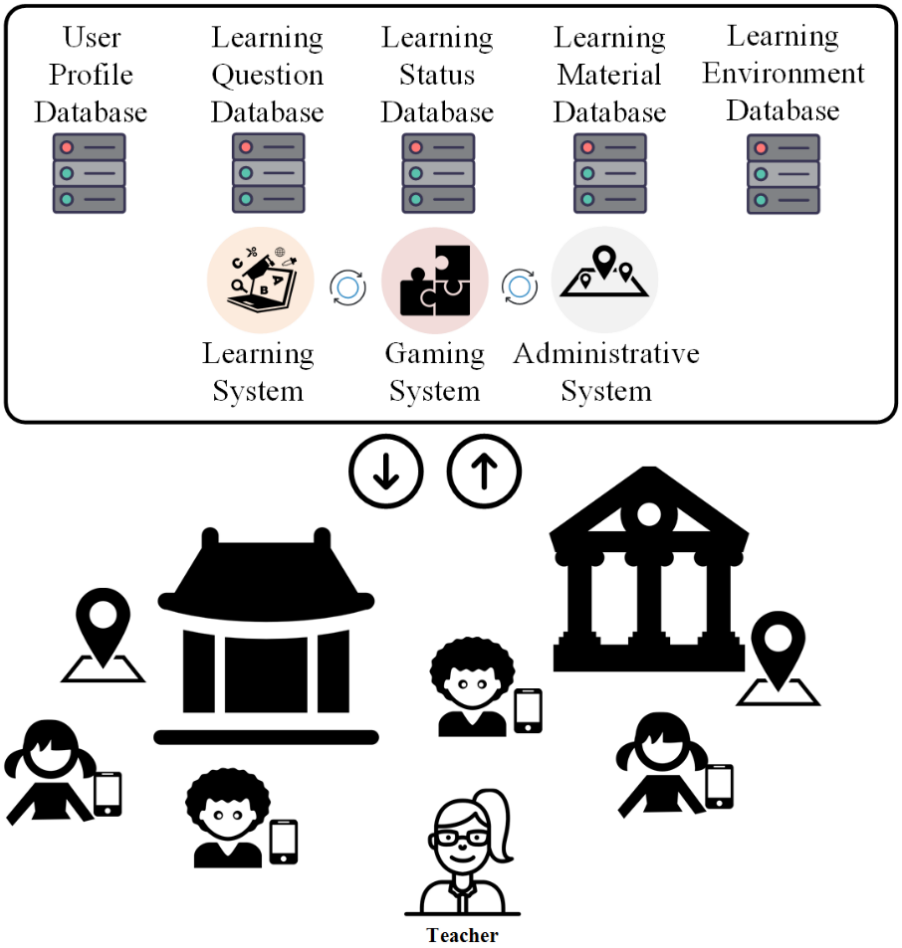

Figure 1. The architecture of the learning application

To support the proposed DGBL approach, the gaming system was designed to deliver gaming content to the students. The game style of this application is a kind of tile-matching puzzle game, as shown in Figure 2(a). To improve the students' learning motivation, this study designed various virtual roles in the game that have different abilities to assist the students in achieving game tasks and further motivating them to collect virtual roles, as shown in Figure 2(b).

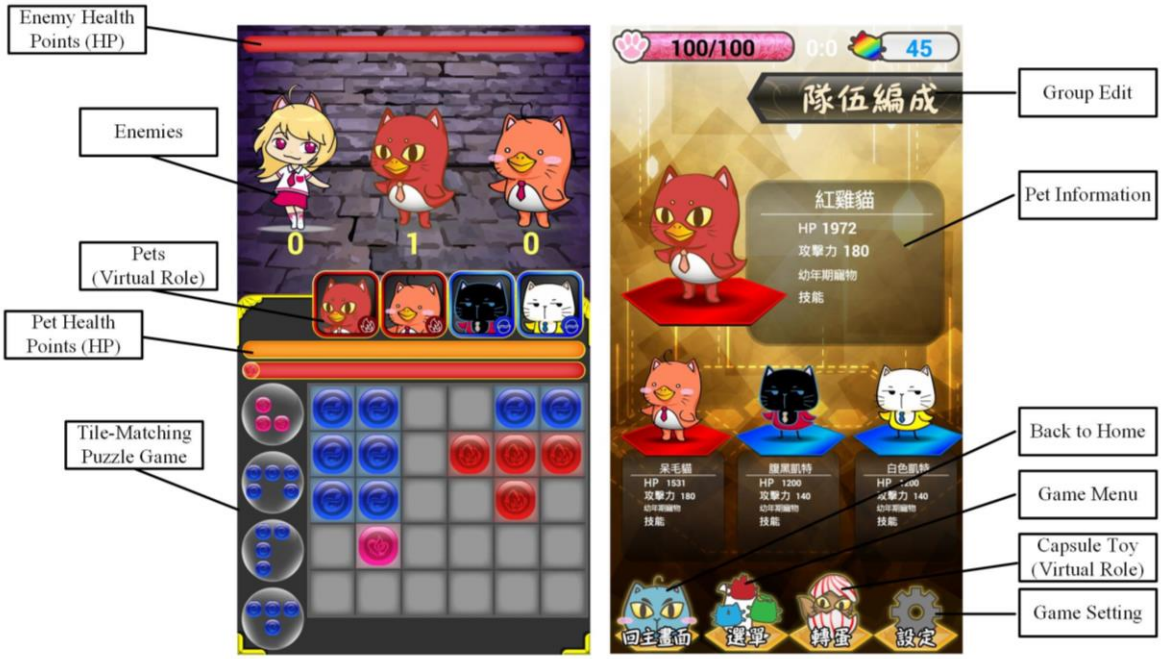

Figure 2. Snapshots of the gaming interfaces

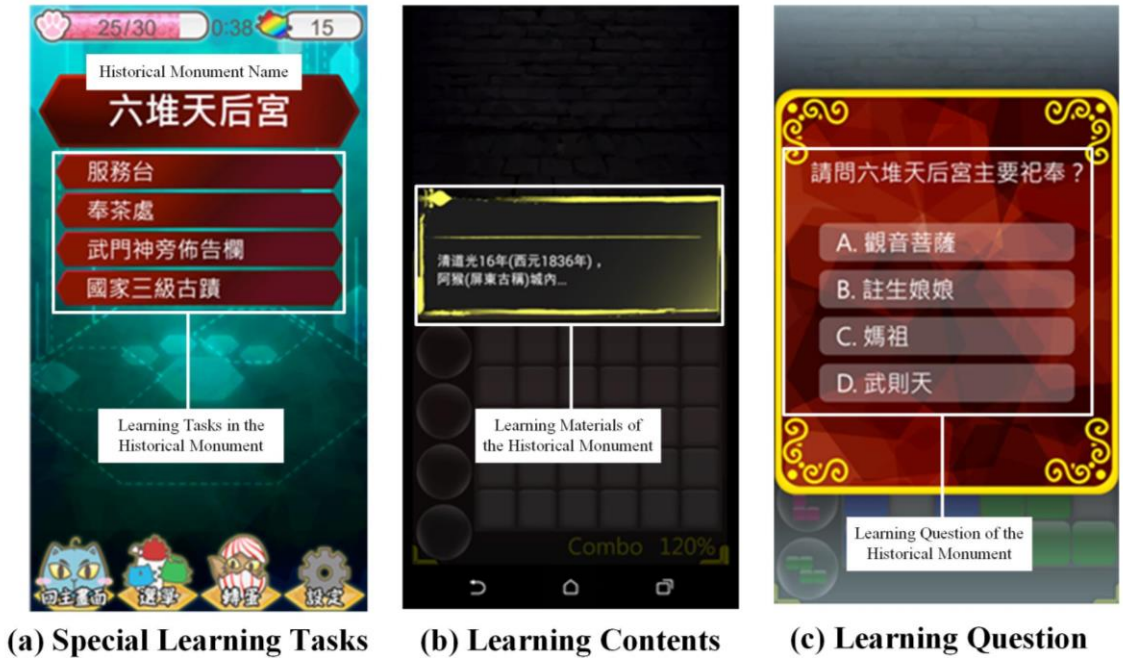

Figure 3. Screenshots of the learning interfaces

Moreover, to promote the students' local cultural learning, the administrative system could be used to detect whether any historic monuments were near the students' location based on government open data in the Taiwan and GPS technique. The administrative system could also guide the students to visit historic monuments in the learning environment and further unlock limited virtual roles and special game tasks for students with regard to a particular historic monument, as shown in Figure 3(a). Furthermore, before starting the special game tasks, the learning system would push relevant learning materials to encourage the students to learn the knowledge about the historic monument, as shown in Figure 3(b). While engaging in the game tasks, as shown in Figure 2(a), the learning system would push the historic monument questions and ask the students to answer the questions, as shown in Figure 3(c). The students could obtain extra power in the game from the gaming system when the questions were answered correctly. The extra power assisted the students in completing the game tasks easily and further collecting limited virtual roles. In addition, the students could share and post personal learning and game achievements with peers on Facebook through the administrative system. Therefore, to collect rare virtual roles

in the game and share individual achievement on Facebook, the students were required to repeatedly visit specific historic monuments and learn relevant knowledge from the historic monuments and the application.

As mentioned above, to store each learning resource and the gaming content, corresponding databases for the proposed application were deployed, including a learning material database, a learning question database, a user profile database, a learning status database, a learning environment database, and a virtual role database. The learning material database is a knowledge collection of historic monuments. The learning question database includes several pieces of information, such as item and answer information. The user profile database stores personal profiles that include students and instructors. The learning status database contains the learning and gaming status of individual students. The learning environment database includes information about historic monuments, such as geographic information. The virtual role database is used to store the information of each role presented in the game.

Experiment

The purpose of the SoLoMo-based DGBL approach is to promote instructors and students to conduct outdoor local cultural learning through the use of the proposed application. This study aims to apply the proposed approach and application to engage the students in achieving each learning target and further assist them in learning relevant knowledge continuously and repeatedly. To evaluate the effect of the proposed approach, the experimental design and settings are described as follows.

Subject

To determine whether the proposed approach truly enhances student learning performance on local cultural learning, a quasi-experiment was conducted on a local cultural learning course at an elementary school in southern Taiwan. The subject of this experiment was conducted on historical monuments in the students' hometown. The course had a length of 370 minutes, including pre-, post-, and delayed tests. A total of thirty-eight students and an instructor were asked to participate in this experiment. The age of the students ranged between 9 and 10 years of age. All of the students learned the subject first, and they had used mobile devices for 2 years on average. One group of eighteen students served as the control group. The other group of twenty students served as the experimental group. The experimental group was supported by the SoLoMo-based DGBL approach with the proposed application to conduct the course, while the control group was supported by a conventional mobile learning approach without the proposed application. The control group adopted a conventional mobile learning approach rather than a conventional digital game-based learning approach because the purpose of the conventional digital game-based learning approach is to provide a pure digital learning game that does not focus on supporting real-world interactive functions in the game for outdoor learning (Coller & Scott, 2009; Homer et al., 2018; Vasalou et al., 2017). To support the conventional mobile learning approach, a local cultural learning platform was developed, and the learning materials on the learning platform included text descriptions and pictures of the historical monuments. The learning materials and questions for the learning application and learning platform for the two groups were the same.

Research instruments

To evaluate the effect of the proposed approach on student learning performance, various data sources were analyzed, including prior knowledge tests, learning achievement tests, delayed tests, and questionnaire results. The prior knowledge test was designed to assess the students' knowledge level with regard to the subject of the historical monuments in their hometown before participating in the activity. The learning achievement test was designed to evaluate the students' learning results after the conclusion of the activity. The delayed test was used to investigate the learning retention of the students after leaving the activity completely. In this study, two teachers were asked to develop the three tests together, and they had each taught the course for more than 6 years. The three tests included 10 multiple-choice test items, and the maximum score of the tests was 100 points. Moreover, the KR-20 reliability of the prior knowledge test, learning achievement test, and delayed test were 0.722, 0.731, and 0.716, respectively. The item discrimination index for most items was greater than 0.35, implying that the items had discrimination validity (Doran, 1980). In addition, three questionnaires were adopted to capture the students' learning motivation, learning attitude, and acceptance of the proposed application.

With regard to the investigation of the students' learning motivation, a questionnaire was used from the intrinsic motivation scale of the MSLQ (Motivated Strategies for Learning Questionnaire) developed by Pintrich and De Groot (1990). The learning motivation questionnaire consisted of nine items with a seven-point Likert scale, where "7" represented "strongly agree" and "1" represented "strongly disagree." The learning motivation questionnaire was used to measure students' goals and beliefs about the importance and interest of the gaming approach. The pretest and posttest Cronbach's alpha values of the questionnaire were 0.868 and 0.899, respectively.

Students' learning attitude was surveyed using a learning attitude questionnaire which has been applied by several studies to measure students' learning attitudes toward learning activities in various courses (Hwang & Chang, 2011; Lin, Wen, Jou, & Wu, 2014). A total of seven items with a four-point Likert scale were included in the questionnaire, where "4" represented "strongly agree" and "1" represented "strongly disagree." The pretest and posttest Cronbach's alpha values of the questionnaire were 0.756 and 0.799, respectively.

The questionnaire for the acceptance of using the proposed application included two scales, "the ease of use of the proposed application" with three items and "the usefulness of the proposed application" with four items (Lin & Lin, 2016; Wu, Hwang, Tsai, Chen, & Huang, 2011; Wu, Hwang, Su, & Huang, 2012). The questionnaire adopted a six-point Likert scale, where "6" represented "strongly agree" and "1" represented "strongly disagree." The Cronbach's alpha values for those two scales were 0.785 and 0.706, respectively; the Cronbach's alpha value of the entire questionnaire was 0.772.

Experimental procedures

Figure 4 shows the experimental process. Students in the experimental group and the control group were asked to take a 20-minute pretest before undergoing the local cultural learning activities. The pretest was conducted to capture the initial learning motivation and learning attitude of the two groups by using the learning motivation questionnaire and learning attitude questionnaire. Moreover, the instructor used 60 minutes to introduce the subject of the historical monuments in their hometown to the students in the classroom. Following that, the students took a 30-minute prior knowledge test, which aimed to evaluate whether the two groups of students had an equivalent basic prior knowledge of the subject learning content.

Before participating in the outdoor learning activity, the students in the control group and experimental group first received a 20-min instruction with regard to the conventional mobile learning approach and the SoLoMo-based DGBL approach in the classroom. Furthermore, the students in the two groups obtained a 30-min lesson with regard to the operation of the mobile learning devices. During the 120-minute outdoor learning activity, the students in the experimental group learned with the proposed application and engaged in the SoLoMo-based DGBL approach. On the other hand, those in the control group learned with the conventional mobile learning approach; that is, the instructor engaged the students in the real-world learning environment for observing and learning about the historical monuments. Simultaneously, the students used the mobile devices to learn using digitalized learning materials from the local cultural learning platform.

The learning environment was an old temple located in southern Taiwan, and there were four learning targets in the temple that needed students to observe and learn relevant knowledge during the learning process. The students in the experimental group and control group visited and observed the temple guided by the learning application and learning platform, respectively. For the students in the experimental group, the learning application unlocked limited virtual roles and four game tasks for the students with regard to the temple. Each game task corresponded to a learning target and involved learning material and two questions with regard to the learning target. The students in the experimental group were asked to engage in the digital game after learning the historical monument knowledge and answer the historical monument questions during the gaming process. For the students in the control group, the learning platform provided the same learning materials and questions provided to the experimental group to the students with regard to the four learning targets. The students in the control group were asked to answer the questions on the learning platform after learning the historical monument knowledge. The students in the two groups conducted the above learning process without constraints. In other words, the students did not need to answer all questions correctly, and they could also learn about other historical monuments.

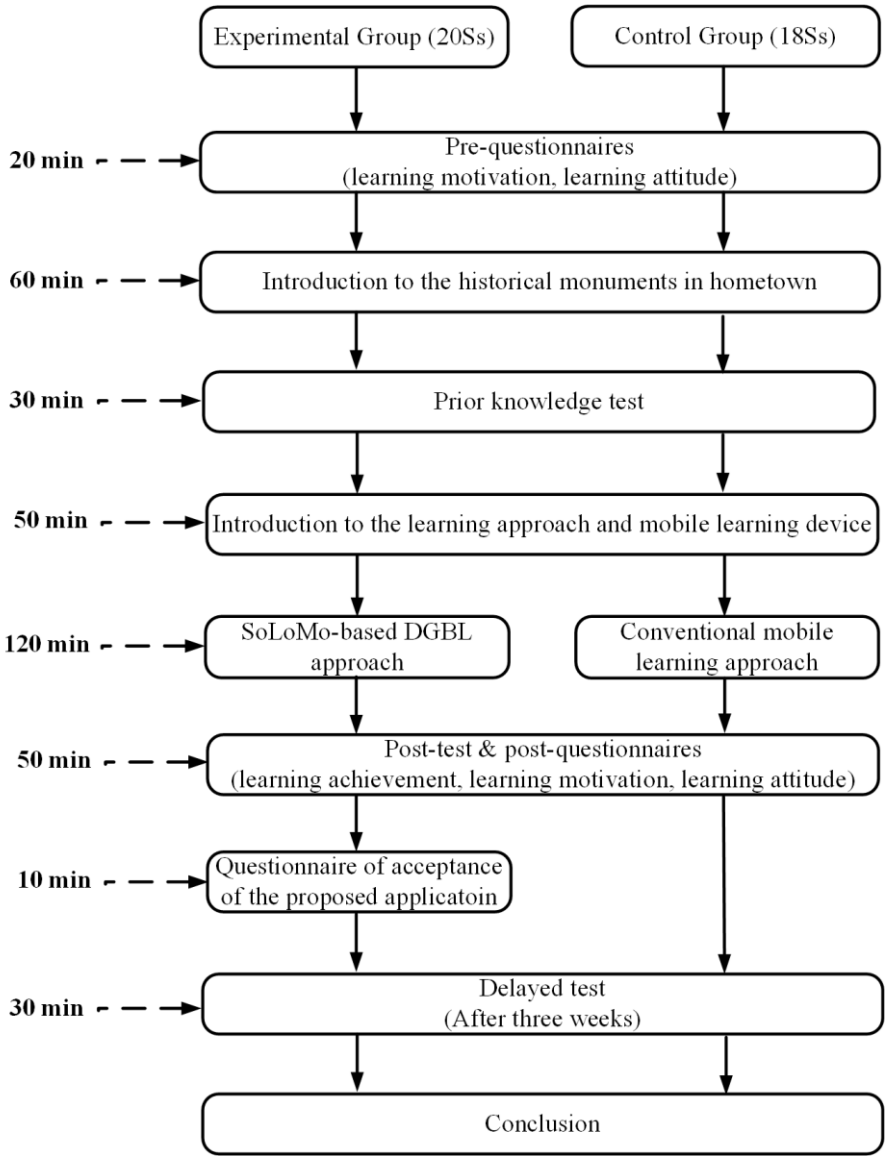

Figure 4. The experimental process

After participating in all of the learning activities, all students from the two groups received the two questionnaires of the posttest to capture their learning motivation and learning attitude. Additionally, the learning achievement test was used to evaluate the historical monument knowledge they learned in the activities. Furthermore, the students in the experimental group were asked to take the system acceptance questionnaire to survey their perceptions with regard to the ease of use and usefulness of the proposed application. In addition, after three weeks, all students in this experiment were asked to take a delayed test to survey their learning retention with regard to the historical monument. Finally, the entire experimental process was concluded once all procedures were completed.

Results

IBM SPSS was applied to analyze the performance of the students in the experiment, including the results of the prior knowledge test, learning achievement test, delayed test, learning motivation questionnaire, learning attitude questionnaire, and acceptance of the proposed application.

Analyses of prior knowledge, learning achievement, and delayed test

To evaluate the equivalency of the students' background knowledge with regard to the subject of the historical monuments in their hometown before participating in the learning activities, an independent *t*-test was applied to

analyze the prior knowledge test results between the two groups. Before the analysis, a Shapiro-Wilk test was used to examine the normality of the above data since the participating students were fewer than 50 samples in the experimental group and control group. The value of this test was 0.943 ($p > .05$), indicating that the sample satisfied the assumption of normality. Furthermore, Levene's test for equality of variances was statistically insignificant ($F = 0.084$, $p = 0.773 > 0.05$) and therefore indicates that the group variances could be treated as equal. The t-test result revealed that there was no significant difference between the experimental group and the control group ($t(36) = -1.221$, $p = 0.230 > .05$). The results implied that the students' prior knowledge with regard to the subject of the historical monuments in their hometown in both groups was statistically equivalent before undergoing the course.

To investigate the effectiveness of the proposed approach for improving the learning achievement of the students regarding the subject of historical monuments in their hometown, one-way independent sample analysis of covariance (ANCOVA) was used to exclude the difference between the prior knowledge of the two groups. To conduct the ANCOVA, the learning achievement and prior knowledge test scores were treated as the dependent variable and covariate, respectively, and the homogeneity of the regression coefficient was tested first. The result confirmed the homogeneity of the regression coefficient ($F = 0.159$, $p > .05$). Table 1 shows the ANCOVA results of the learning achievement for the two groups. The adjusted means and standard deviations were 83.20 and 3.43 for the experimental group and 71.99 and 3.62 for the control group. There was a statistically significant difference between the adjusted means ($F(1,35) = 4.953$, $p = 0.033 < 0.05$). Moreover, the learning achievement of the experimental group was significantly higher than that of the control group. The results reveal that the SoLoMo-based DGBL approach with the proposed application in local cultural learning benefited the students more than the conventional mobile learning approach in local cultural learning with regard to learning achievement.

Table 1. The ANCOVA results for the students' learning achievement

Group	Number of students	Mean	*SD*	Adjusted mean	Adjusted *SD*	*F*	*p*-value
Experimental	20	83.00	9.23	83.20	3.43	4.953	0.033*
Control	18	72.22	19.57	71.99	3.62		

Note. $^{*}p < .05$.

To further evaluate the learning retention of the students with regard to the subject of the historical monuments in their hometown, the students in both groups were asked to take a delayed test three weeks after completing the experiment. An independent t-test was applied to analyze the scores of the delayed test between the two groups. Before the analysis, a Shapiro-Wilk test was used to examine the normality of the above data since the number of participating students was less than 50 in the experimental group and control group. The value of this test was 0.948 ($p = 0.079 > .05$), indicating that the sample satisfied the assumption of normality. Furthermore, Levene's test for equality of variances was statistically insignificant ($F = 3.574$, $p = 0.067 > 0.05$) and therefore indicates that the group variances could be treated as equal. The t-test result revealed that there was a significant difference between the experimental group and the control group ($t(36) = 2.177$, $p = 0.036 < .05$). The result implies that the proposed approach significantly benefited the students in terms of learning retention.

Analyses of learning motivation and learning attitude

To analyze whether there were any significant differences between the means of the learning motivation of the two groups after engaging in the entire learning process, ANCOVA was used to exclude the difference between the pretest of the learning motivation of the two groups, and the posttest and pretest scores for learning motivation were treated as the dependent variable and covariate, respectively. The homogeneity of the regression coefficient was not violated ($F = 0.030$, $p = 0.863 > 0.05$). Table 2 shows the ANCOVA results of the learning motivation for the two groups. The adjusted means and standard deviations were 5.78 and 0.11 for the experimental group and 5.39 and 0.11 for the control group. There was a statistically significant difference between the adjusted means ($F(1,35) = 6.054$, $p = 0.019 < 0.05$). The result implies that the proposed approach significantly benefited the students in terms of learning motivation.

Table 2. The ANCOVA results for the students' learning motivation

Group	Number of students	Mean	*SD*	Adjusted mean	Adjusted *SD*	*F*	*p*-value
Experimental	20	5.74	0.64	5.78	0.11	6054	0.019*
Control	18	5.43	0.58	5.39	0.11		

Note. $^{*}p < .05$.

To evaluate the equivalent of the students' learning attitude with regard to local cultural learning before participating in the learning activities, an independent *t*-test was applied to analyze the pretest scores of learning attitude between the two groups. Before the analysis, a Shapiro-Wilk test was used to examine the normality of the above data because the participating students were fewer than 50 in the experimental group and control group. The value of this test was 0.945 ($p = 0.061 > .05$), indicating that the sample satisfied the assumption of normality. Furthermore, Levene's test for equality of variances was statistically insignificant ($F = 0.380$, $p = 0.541 > 0.05$) and indicates that the group variances can be treated as equal. The *t*-test result revealed that there was no significant difference between the experimental group and the control group ($t(36) = 0.042$, $p = 0.966 > .05$). The result implies that the two groups of students had an equivalent awareness of their learning attitude before entering the course.

In addition, an independent *t*-test was performed on the rating scores to compare the posttest scores of the learning attitude between the two groups. The values of the Shapiro-Wilk test and Levene's test were 0.953 ($p = 0.113 > .05$) and 0.594 ($p = 0.446 > 0.05$), indicating that the sample satisfied the assumptions of normality and homogeneity. The analysis result indicated that there was no significant difference in the posttest scores of learning attitude between the two groups ($t(36) = 0.436$, $p = 0.066 > .05$). The result reveals that the student learning attitude with regard to local cultural learning in both groups was also statistically equivalent after undergoing the learning activities.

Analysis of system acceptance

The analysis of the acceptance of the proposed application is shown in Table 3, which shows that most students in the experimental group gave positive evaluations. The four questions of the ease of use scale had a mean value exceeding four, indicating that the students evaluated the ease of use of the application positively. It was also observed during the experiment that the students, after being taught once or twice, were familiar with the application operations and learning contexts. For the usefulness scale, all of the questions with a mean value exceeding four represent that a positive evaluation was also provided by the students.

Table 3. Analysis of the acceptance of the learning application

Scale	Item	Mean	*SD*
Ease of Use	1. It is easy to operate the mobile device interfaces of the mobile learning application	5.10	0.17
	2. It is easy to read information on the mobile device screens of the learning application	4.95	0.18
	3. The response speed of the learning application is well-matched with the learning progress in the field	5.15	0.19
	4. I think that mobile device operation of the learning application is easy	5.25	0.17
Usefulness	5. The learning functions provided by the learning application can benefit my learning achievement	5.20	0.18
	6. The operations of the learning application are quite clear and effectively assist me to understand the learning tasks	5.30	0.14
	7. Combining the learning system and the real-world contexts is helpful to learning	5.20	0.20

Discussion and conclusions

This study developed an Android-based mobile game application with a SoLoMo-based DGBL approach to support outdoor local cultural learning activities. An experiment was conducted to evaluate the effectiveness of the proposed approach. The experimental results showed that, compared with the conventional mobile learning approach, the proposed approach significantly improved student learning achievement, learning retention, and learning motivation. Furthermore, most students in the experimental group agreed with the ease and usefulness of the proposed application in the local culture course.

These findings provide evidence that the proposed approach can benefit students in terms of local cultural learning. From the aspect of learning achievement, the proposed application applied in the proposed approach provided a suitable learning and gaming tool for the students. This result was consistent with the literature because appropriate learning and gaming activities have a significant direct effect on achievement in a DGBL environment (Chen, Wang, & Lin, 2015; Hwang & Wang, 2016). From the view of learning motivation, this

study designed various virtual roles in the proposed application that could assist the students in collecting roles during the learning process. This design was consistent with past research findings, which noted that effective game design in a digital game-based learning process is an important indicator of student learning motivation (Mathrani, Christian, & Ponder-Sutton, 2016). Furthermore, with regard to learning attitudes, past investigations have indicated that mobile learning approaches and DGBL approaches can improve student learning attitudes (Chao, Chang, Lan, Kinshuk, & Sung, 2016; Chen, Shih, & Ma, 2014; Sáez-López, Miller, Vázquez-Cano, & Domínguez-Garrido, 2015). In this study, the student learning attitudes in both groups were improved, and thus, there was no statistical difference between the two groups. In addition, from the social aspect, the proposed application helped the students to connect with peers that could benefit the students' learning motivation (El-Bishouty et al., 2010). From the local view, the proposed application engaged the students in an authentic learning environment that enhanced the students' learning achievement (Chu, Hwang, & Tsai, 2010). With regard to the mobile perspective, the proposed application effectively and efficiently connected the digital-world and real-world learning resources to promote the students' learning attitude (Hwang, Wu, & Ke, 2011).

To support local cultural learning, several studies have indicated that the SoLoMo-based learning approach can benefit students in terms of their learning performance (Hwang, Chang, Chen, & Chen, 2018; Shih, Chuang, & Hwang, 2010; Sung et al., 2016). Furthermore, a previous study noted that local culture and history subjects are difficult and boring for students since they only memorize the facts about the local culture and history (Zin, Jaafar, & Yue, 2009). Therefore, several studies have suggested that DGBL is an appropriate educational approach to promote students' local culture and history learning effectiveness (Akkerman, Admiraal, & Huizenga, 2009; Huizenga et al., 2009; Zin et al., 2009). As mentioned above, this study proposed a mobile game to integrate the SoLoMo-based DGBL approach in a local culture course. During the learning and gaming process, the students could only collect limited virtual roles when they were near a particular historical monument and completed special learning tasks. To complete the special learning tasks successfully, the students were required to answer historical monument questions by themselves. These features directed the students to deeply and actively engage in the learning processes. When actively engaged in learning activities and learning processes, students generally show more effective learning achievement and motivation than when learning passively (Hwang et al., 2018; Wood, 2015). Furthermore, with regard to the students' perceptions of the learning application, although this study did not arrange a formal interview with the students in the experimental group, some feedback was collected from the students during the learning process. In addition to the positive evaluation of the system acceptance from the questionnaire, the students indicated that the user interface and game operation of the learning application were clear and straightforward. In addition, the students stated that they liked to collect the virtual roles in the game since the art design of the virtual roles was attractive to them. The system design mentioned above also benefited the students in actively using the learning application and engaging in the learning process (Wei et al., 2016).

To further discuss the above findings of this study with the literature on SoLoMo-based systems, relevant surveys are presented as follows. Chiang et al. (2014), Hwang, Wu, Chen, and Tu, (2016), and Hwang et al. (2018) proposed augmented reality-based mobile learning systems to support outdoor natural science courses and local culture courses. The mobile learning systems mainly involved learning discussion function (social), location-based guidance function (local), and mobile augmented reality function (mobile) to support outdoor learning. The experimental results indicated that the augmented reality-based mobile learning approach significantly enhanced student learning motivation and learning achievement. The results in the literature are consistent with the results of the present study. Nevertheless, the present study additionally integrated digital game elements into the proposed SoLoMo-based application. This is a major difference compared with the methods reported in the literature regarding motivating students to challenge learning tasks actively and continuously (Buckley et al., 2017; Boctor, 2013). In addition, from a social aspect, the proposed application integrated social network services to facilitate peer connections. From a local view, in addition to location-based learning materials and questions, the proposed application also provided location-based digital game elements to attract students to engage in learning tasks repeatedly. With regard to a mobile perspective, the proposed application applied cloud computing and databases to reduce the device computing load and enhance device mobility.

In sum, the major contribution of this study is to promote local cultural learning for instructors and students. Based on the proposed approach, this study has some limitations and future directions. As the sample size of the experiment was not large, this study needs to conduct experiments with more relevant learning subjects to cover various samples and provide additional evidence. In addition, the short term of the learning session in the experiment is another limitation of this study. To facilitate human-computer interaction in outdoor mobile learning environments, a modern technique, named beacon, will be integrated with the proposed application to

determine the microposition of the students and further provide intelligent learning services for instructors and students.

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