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LONG PAPER

Investigating the effects of ubiquitous self-organized learning and learners-as-designers to improve students' learning performance, academic motivation, and engagement in a cloud course

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Abstract

In the past decade, the developments of the Internet and educational technologies have facilitated innovative approaches to modern education. In addition, computers and related software are used in all professional fields of the workplace; therefore, students should acquire related essential abilities before they enter the workforce. Teachers should devote attention to designing and implementing appropriate online teaching methods and guiding their students to adopt suitable learning strategies to develop related abilities and improve their learning effectiveness. Thus, in this study, two innovative teaching methods, namely self-organized learning (SOL) and learners-as-designers (LaD), were integrated with educational technology and ubiquitous learning (u-learning) to develop students' computing skills, academic motivation, and engagement in a blended course. A quasi-experiment was conducted to examine the effects of ubiquitous SOL and LaD. The experiment used a 2 (SOL vs. non-SOL) × 2 (LaD vs. non-LaD) factorial pretest–posttest design. First-year students from four classes who were taking a one-semester university course titled "Applied Information Technology: Data Processing" were the participants in the empirical study. The results revealed that students who received the ubiquitous LaD intervention exhibited significantly improved computing skills compared with those of students who did not receive the intervention. However, the ubiquitous SOL intervention did not enhance students' computing skills, academic motivation, or engagement. The study results may be used as references for online educators when designing an online, cloud, or ubiquitous course for their students.

Keywords Ubiquitous self-organized Learning · Ubiquitous learners-as-designers · Computing skills · Academic motivation · Engagement

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1 Introduction

With the rapid growth of educational technologies, the features of learning environments and teaching approaches have undergone considerable changes [18]. Information and communication technologies (ICTs) reduce the limitations on higher education services, including the restrictions of location and time [3]. However, various studies have indicated that many online courses lack design considerations, and that the network is only used as a delivery medium [16, 23]. Thus, in this study, a course was redesigned using an appropriate online teaching method based on the need for innovative and effective online methods, which are described in the following subsections. To enhance students' learning, two innovative teaching methods, namely self-organized learning (SOL) and learners-as-designers (LaD), were integrated with educational technologies and ubiquitous learning (u-learning)—a set of educational processes that can support learning anywhere, at any time, and on any device and are contextualized and integrated into learners' daily lives [7, 108].

1.1 Adoption of self-organized learning

Advances in the Internet and educational technologies have gradually transformed learning paradigms from traditional in-classroom textbook learning to e-learning [46]. In addition, computers are used for many educational purposes [53]. However, in the education field, e-learning strategies often focus on technology and are developed without consultation with instructors, thus creating tension between an institution and its academics [72], which can even affect students' learning outcomes. Therefore, instructors should devote attention to providing appropriate online teaching methods and guiding students to adopt suitable learning strategies to enhance their learning performance [102]. Hence, in educational technology research, developing methods to enhance learners' engagement in learning is important [42].

Technical and vocational skills are generally considered tools that should be fully utilized by the workforce [83]. Although many students are technically skilled in using the Internet, their abilities to use it to critically and meaningfully process information are often less well developed [59, 74, 89, 96]. Students should acquire technological skills while studying in university because they may need these essential abilities when they enter the workforce [56, 62]. Therefore, students must develop ICT skills and learn to be adaptable, flexible, and oriented toward problem solving [94].

Many educators are concerned with designing activities that not only engage students productively but also motivate them toward self-learning [79]. Students often feel overwhelmed by the complexity of knowledge and information [22]. When entering university, students often lack technological skills and are thus required to quickly develop various capabilities to achieve success; however, during their first year of university, many students find new learning approaches difficult and feel stressed [82]. Therefore, appropriate teaching approaches should be adopted for these students.

One such teaching approach, SOL, enables students to work in groups, access the Internet and other software, access course activities or projects, and follow their own interests [77]. SOL environments potentially disturb the classroom ecology because the teacher shifts from being on the center stage, and learner autonomy is expected because of the enquiry-based approach [32]. Many researchers and educators have incorporated media, mobile, and educational technologies into their teaching approach and learning environments to promote students' interest in learning [84]. Therefore, the researchers in this study regarded SOL as a teaching strategy in which students manage their learning processes with Internet and educational technologies, and adopted it in a u-learning environment and a cloud classroom to develop students' practical computing skills, motivation, and engagement.

1.2 Need for learners-as-designers

In recent years, many higher education institutions have adopted virtual learning environments and have incorporated e-learning into their traditional teaching mechanisms as part of a blended learning approach [35]. Teenagers who have grown up with computers, the Internet, video games, and smartphones have been termed "digital natives" [88]. Because of their early use of and constant engagement with ICT, these young people are believed to differ substantially from previous generations in terms of learning styles, social practices, and even cognition [14]. The phenomenon of Internet addiction among students and the emergence of smartphones and free mobile applications (APP) pose considerable challenges for teachers and students because these factors often distract learners from involvement in an online learning environment [100, 103], potentially leading to unsatisfactory learning performance.

To help students focus on their learning, develop their interests, and become more involved in a blended course, an LaD approach was adopted in this study. This approach provides learners with the authoring tools to design instructional materials for themselves [51], and enables students to display their creativity, innovation, and talents [10]. Educators should re-conceive classrooms as places in which subcommunities of learners simultaneously play the roles as learners, as designers, and as active contributors [71]. The value-added role of ICT is attributed to how it is applied in education rather than its mere existence in the classroom or its particular characteristics [38, 54]. Thus, the researchers in this study regarded LaD as a teaching pedagogy which empowers students so that they can design their own instructional materials, and have the opportunity to include their innovation and creativity beyond the teacher's arrangement; the researchers integrated LaD with online learning technologies to explore its effects on improving students' online learning outcomes.

The development of the Internet has created new lifestyles because of its application as a wide-ranging mass medium [52]. In educational environments such as universities, the e-learning process is managed through diverse tools that facilitate interaction, providing abundant opportunities for students to collaborate with teachers, experts in the field, professionals, and other students [30]. Online education has developed considerably, and its application to various fields has increased [55, 109]. However, online education providers are producing courses whose goals are implicit but unstated in the procedural descriptions of their use in the context of school classrooms or informal alternative education settings where students learn online [49]. Therefore, to enhance students' learning performance, academic motivation, and engagement in a cloud course, for this study, SOL and LaD were integrated with u-learning, and a quasi-experiment was conducted to explore the effects of ubiquitous SOL and LaD.

2 Literature review

2.1 Self-organized learning

The concept of self-organized learning (SOL) is related to curriculum which connects much stronger to students' interests, experiences, and questions [85] than typical curricula. SOL is an innovative teaching pedagogy and could bring about positive learning results for students [75, 77]. In SOL, self-organized groups of students govern the learning process by themselves, as they learn through using ICT with minimal teacher support [32, 73].

When students enter an SOL environment, the sessions take place in a school classroom that involves a session of between 30 and 90 min during which the teacher could engage the students with a question that they address [32]. A characteristic of SOL is that the group process is seldom supervised by teachers. It has potential as a divergent, flexible and radical transformative pedagogy [32]. Instructors provide Internet-based learning experiences for groups that are driven by a research question [77, 114]. In addition, social networks play an important role in implementing SOL, because they can provide opportunities for students to discuss, communicate and respond [73].

In university learning tasks, students have to get involved with self-discipline [97]. The effect of SOL on students' learning is that students in an SOL environment all have high achievement [32]. Student agency seems much better in SOL than that in typical teacher-directed lessons [99]. Moreover, it is indicated that an SOL environment is meaningful in education, as it can maintain learning outcomes, such as enhanced exam results, better [32]. In recent research, it is reported that in an SOL environment, students can retain what is learned over time and enjoy the process to further explore on their own [76]. Thus, it is believed that SOL could improve students' learning and was adopted in this study to investigate its effects on enhancing students' learning performance, motivation and engagement in a blended computing course.

2.2 Learners-as-designers

Learner-as-designer (LaD) is a term for giving authoring tools to learners, so that they can design instructional material themselves, and providing the opportunity for them to concurrently use several generative activities independently from instructions of a teacher [51]. The critical factors of LaD, such as listing the design process clearly to students, having teachers familiar with apprenticeship techniques, scaffolding and practicing, may lead students to better learning performance [17]. In addition, it is also reported that in an LaD environment, learners are actively engaged in designing knowledge and relationships rather than in encoding information independently [86]. Students in such a constructionist learning environment can accept tools and strategies, and could be encouraged to become designers of their own projects [8].

With regard to the effects of LaD on students' learning, it is indicated that LaD can assist students with a better understanding of the concept of accounting while building a web-based platform to help others to learn [4]. Researchers have investigated the learning outcomes of LaD, and demonstrate that students involved in an LaD environment show significant increase in both intrinsic motivation scores and self-efficacy scores, as well as understanding of several critical design skills after participation in this means of learning [64, 69]. Moreover, Liu [67] designed multimedia programs to explore how an LaD environment affects students' motivation and their knowledge of design. After participating in the LaD environment, students are more intrinsically motivated, interested, have confidence to finish the tasks and acquire important design skills. Furthermore, it is also reported that, based on students' interpretations of the course, allowing learners to be the designers of their own computer games can realize their full potential [66]. Therefore, the researchers in this study adopted LaD and explored its effects on improving students' learning performance, motivation and engagement in a ubiquitous learning environment.

2.3 Ubiquitous learning

Ubiquitous or u-learning refers to a learning model in which learners can learn anytime, anywhere, with the aid of portable computer technology such as mobile devices, RFID tags, and wireless sensor networks [80, 81]; Wu et al. [112]. It not only enables learners to achieve their learning goals at any given time or location but also cultivates their ability to gain new knowledge and develop problem-solving abilities [70]. U-learning can be regarded as a promising approach that provides students a means to interact with real-world learning targets with support from the digital world [112]. It has been extensively used and researched in different fields, such as computer science, linguistics, natural science, and so on [20, 45, 61, 70, 113].

An educational environment integrated with u-learning can enhance the students' learning efficiency significantly for both individual and collaborative learning modes, and satisfy their learning in terms of functionality and adaptability [98]. Many studies address the effects of applying u-learning on the enhancement of learning effectiveness [34, 47, 92]. U-learning not only promotes students' academic motivation but also enhances the learning achievements of individual students [21]. Furthermore, students' learning achievements have been significantly improved in terms of several cognitive processes [112]. Thus, u-learning approach and related technology were applied and integrated with the implementation of SOL and LaD to enhance students' learning performance, motivation, and engagement in this research.

2.4 Academic motivation

Academic motivation is grounded in robust theoretical and empirical research and has been defined as the physiological processes involved in the vigor, direction, and persistence of behavior [33, 78]. Motivation for learning is not only an important concept in education, but also a crucial condition for success that promotes students' actions to perform the activities needed for learning [105]. It is found that students who are highly motivated and self-regulated are more likely to persist and succeed in e-learning environments, and optimizing usability can make an important contribution to their satisfaction and motivation [29]. Thus, academic motivation was evaluated as one of the critical factors of students' learning outcome in this study.

In recent years, ICT has been regarded as a promising tool for encouraging students' academic motivation and improving their learning outcomes [19, 44, 48]. However, it is reported that students with insufficient motivation may shift away from online courses [2, 39]. In this regard, the researchers redesigned a blended computing course with innovative teaching methods and technologies, and further explored whether students' academic motivation is improved under different combinations of interventions with ubiquitous SOL and LaD.

2.5 Students' engagement

Engagement refers to students' involvement with conditions likely to generate high quality learning [5, 6]. The concept of engagement has been regarded as a multi-dimensional construct that includes perceived behavioral and affective dimensions [36]. In education, engagement is not only considered in traditional teaching approaches but also in digital media and educational technologies [116]. In addition, recent researchers have emphasized the importance of the enhancement of student's learning engagement through their use of ICT [25, 107, 116].

The advantage of academic engagement is that it has a compensatory effect for students [58]. In higher education, engagement is related to both positive changes in skills, capabilities and greater psychological adjustment during college years [111]. Therefore, students' engagement was regarded as one of the key learning outcomes in this study. The researchers in this study investigated whether students' engagement in a cloud course is improved after they received the interventions of ubiquitous SOL and LaD.

3 The empirical study

3.1 Course setting

The present study enrolled first-year students from non-computing and non-information departments who were taking a semester-long, 2-credit hourly course titled "Applied Information Technology: Data Processing." The course focused on developing students' computing skills for using Microsoft Excel, and the students were required to pass an examination for certification. In this course, the teacher first introduced the basic functions of Excel. Subsequently, the teacher applied the SOL and LaD approaches, described in Sects. 3.3.1 and 3.3.2, respectively, and asked students to design and complete designated sheets and documents in their experimental groups. Finally, in the last week of the semester, the students were required to take an examination for certification in Microsoft Excel.

3.2 Participants

The participants included 135 undergraduates from four classes taking a compulsory course titled "Applied Information Technology: Data Processing." The four classes were as follows: the SOL and LaD class (G1, $n=29$), the SOL and non-LaD class (G2, $n=39$), the non-SOL and LaD class (G3, $n=34$), and the non-SOL and non-LaD class (G4, control group, $n=33$). All students were from the department of finance of a comprehensive university and were taught by the same teacher. All students were from a non-information and non-computing department; thus, they generally lacked the skills necessary to use the software application well. The experimental design of the four groups (conditions) and the hypothesized outcomes are shown in Fig. 1.

3.3 Experimental design and procedure

The study used a 2 (SOL vs. non-SOL) × 2 (LaD vs. non-LaD) factorial pretest–posttest experimental design. Among the experimental groups, the students in the first class (G1) simultaneously received the ubiquitous SOL and LaD interventions, those in the second class (G2) received the ubiquitous SOL intervention alone, and those in the third class (G3) received the ubiquitous LaD intervention alone. The

	SOL	non-SOL
LaD	Most significant effect (G1 Group)	Medium effect (G3 Group)
non-LaD	Medium effect (G2 Group)	No difference (G4 Group)

Fig. 1 Expected effects of different instructional designs

students in the fourth class (G4) received the traditional teaching method (non-SOL and non-LaD) and thus served as the control group, although the teaching was also conducted as part of a blended course. All groups were exposed to a u-learning environment. The course schedule is illustrated in Fig. 2.

3.3.1 Self-organized learning intervention

The students from G1 and G2 received the SOL intervention, which is an enquiry-based approach in which greater student autonomy is expected [32]. In this study, the suggestions of [77] were followed when developing the SOL environment. More specifically, the SOL environment in this study was carried out in the following ways [76].

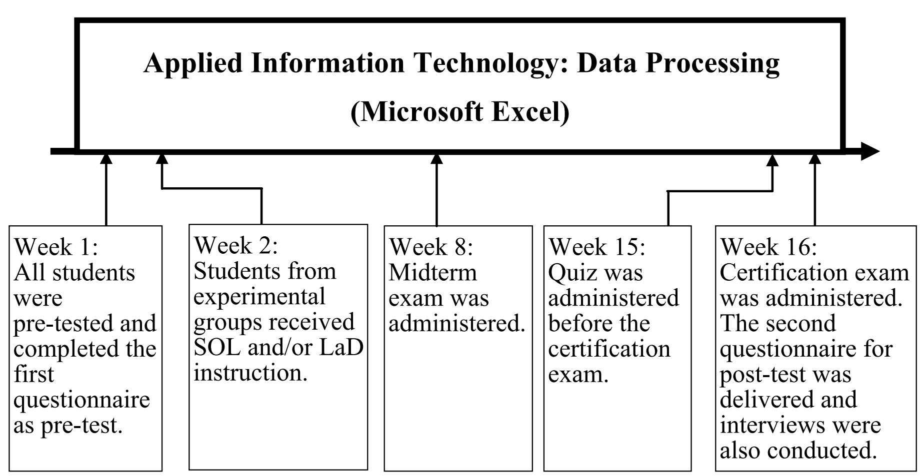
1. *Timetabled usage* G1 and G2 were timetabled at least one SOL environment session of approximately 90 min every week. During this session, the teacher engaged the students with questions for them to solve. During each session, the students formed their own groups, comprising approximately four members, depending on their own choice. They were permitted to change groups, talk to one another or to other groups, and look at each other's work.
2. *Curricular usage* This was similar to the above except that the key question was taken from a simulated certification examination. That is, the question was a simulated situation in which students were asked to design a document or sheet to solve a problem. The question was similar to those appearing on the certification examination which is administered by a trustworthy organization in Taiwan named the Computer Skills Foundation.
3. *Aspirational usage* The students listened to a short lecture about the basic functions of the software package. Subsequently, they researched its application in groups and presented their findings.
4. *Free usage* In addition to access to a computer laboratory with Internet accessibility, the students were provided access to a cloud classroom. The students could log into the cloud classroom anywhere and at anytime and use the cloud classroom software if they did not own the necessary software. All of the necessary learning materials and related documents were accessible in the cloud classroom and ubiquitous environment.

Mathiasen and Dalsgaard [73] have argued that social networking software or web sites can support SOL environments and improve students' discussion forums and file sharing. Therefore, in this study, the teacher encouraged the students to form groups on social networking sites (e.g., Facebook) and online chat app (e.g., LINE) for discussion, file sharing, and problem solving.

3.3.2 Learners-as-designers intervention

Because the LaD concept encourages learning by using computers [51], the students from G1 and G3 were

Fig. 2 Course and certification examination schedule during the semester



required to use computers as tools during the implementation of LaD. This encouraged learners to treat the technologies as knowledge partners [50, 93] also providing opportunities to integrate various types of activities and to apply a diverse set of higher-order thinking skills in a meaningful context [17, 67]. In addition, to enable the students to work with clients to design for a real audience, this computing course adopted the cognitive apprenticeship principles that were applied in the multimedia design programs presented by Liu [67]. Furthermore, the students were required to make decisions regarding content, navigation, presentation, and evaluation [15] and to develop a process to illustrate what they had learned [4].

The implementation of LaD in the present study suggests that a project-based learning approach that emphasizes learners-as-designers could be applied [68]. This approach corresponds with the following four-phase model based on established practices in the multimedia industry and current education technology literature: (1) planning, (2) design, (3) transformation, and (4) revision [27]. As students' documents and sheets, which are designed with software programs, formulas, and functions, evolve with the advancement of technologies, team members' skills are improved and they can reflect on their learning. These LaD processes provide students with opportunities to gain valuable technical development and software design skills [68], as LaD encourages learners to design and produce learning material for others [27].

3.3.3 Ubiquitous learning intervention

In the context of this study, a u-learning system was developed for the four groups. This u-learning system mainly comprised two components: a smartphone or tablet computer and learning management system, which provided access to digital learning material (see Fig. 3). The students could log into the u-learning system and learn the computing skills at any time or place.

Based on students' requests in the u-learning system, the learning management system could deliver content and material to help the students learn computing skills (see Fig. 4). After completing their assignments, the students submitted them to the learning management system through their smartphones or tablet computers. Moreover, the students could request help or discuss with a teammate in this learning management system through their smartphone or tablet computer. Additionally, they could have discussions with their teammates by using the groups formed on social networking sites or online chat APPs.

3.3.4 Control group (G4) intervention

The students in the control group received the same number of hours of instruction and performed the same tasks as those students in G1, G2, and G3. However, they did not receive the SOL or LaD interventions. They joined the blended course, used u-learning technology and material, were taught the basic functions of Microsoft Excel, and solved problems on the examination for the computing

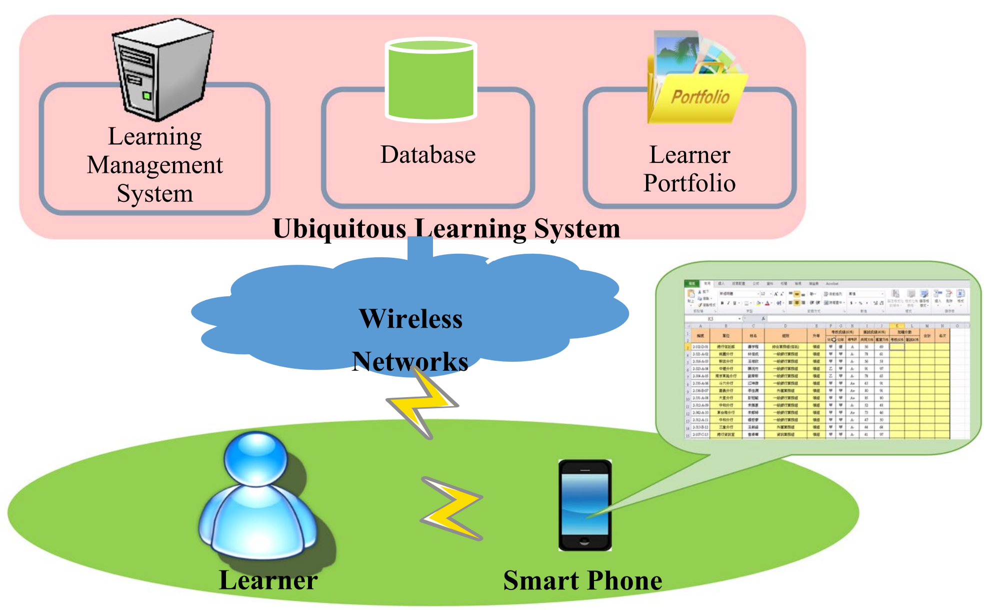


Fig. 3 u-Learning structure followed in this research

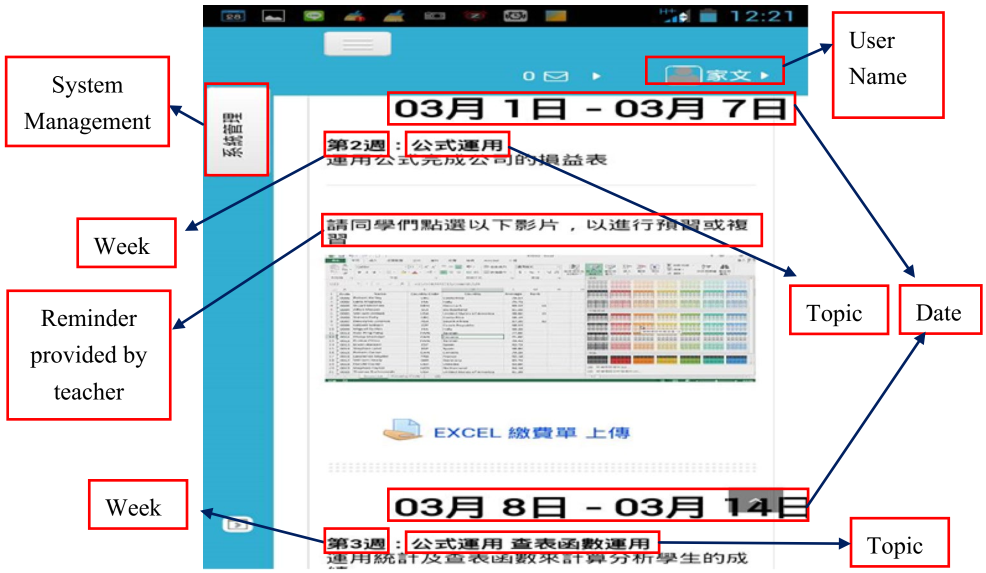


Fig. 4 System interface for u-learning on a smartphone

certification. For the control group, there was no implementation of LaD or the four activities in SOL.

3.4 Measurement

3.4.1 Computing skills

The study explored the effects of ubiquitous SOL and LaD on students' computing skills. To measure their computing skills, the students took an examination for certification in Microsoft Excel, which was conducted by the Computer Skills Foundation during the sixteenth week of the semester. The examination included three main questions, each of which consisted of 7–9 sub-questions. Students' scores were determined according to the correctness and completeness of problem solving. The students were given 40 min to complete the sheets in Excel. The teacher received students' scores from the Computer Skills Foundation 1 week after the examination. The score on this certification examination represents skills in using Excel, so these scores were analyzed to test the effects of ubiquitous SOL and LaD on enhancing students' computing skills in using Excel.

3.4.2 Academic motivation

Motivation is crucial for involving students in academic activities. The strength of learners' achievement motivation is shaped by the value and expectancy that they ascribe to a task [33, 110, 115]. In addition to testing their computing skills, the students from the four classes completed the Motivated Strategies for Learning Questionnaire (MSLQ) developed by Pintrich et al. [87] as pretest and posttest of students' academic motivation. The MSLQ, which assesses expectancy, value, and affect, is an 81-item, self-report instrument. The self-report items are divided into two broad categories: (1) a 31-item *motivation* section and (2) a 50-item *learning strategies* section. Students rated themselves on a 7-point Likert scale, from 1 (*not at all true of me*) to 7 (*very true of me*). In the pretest, the researchers then tested whether any difference of students' motivation existed at the beginning of the experiment.

For the posttest, the students from the four groups completed the MSLQ again during the sixteenth week of the semester. After the posttest, the differences in students' academic motivation among the four groups were analyzed.

3.4.3 Engagement

The teacher asked all students from the four classes to complete the School Engagement Scale, developed by Fredricks et al. [36] to serve as pretest and posttest of students' learning engagement. The School Engagement Scale is a 19-item, self-report instrument. The self-report items are divided into three types: (1) five behavioral engagement items, (2) six emotional engagement items, and (3) eight cognitive engagement items. The students rated themselves on a 5-point Likert scale, from 1 (*not at all true of me*) to 5 (*very true of me*). These scores were used to clarify any differences in the students' engagement among the four groups at the beginning of the semester.

In addition, for the posttest, the students completed the School Engagement Scale during the sixteenth week. Subsequently, the differences in students' engagement among the four groups were analyzed.

4 Results

4.1 Pretests

To avoid measurement bias due to students' initial differences, their Microsoft Excel skills, academic motivation, and engagement were assessed before beginning the experiment. In the first week of the semester, the students from the four classes were asked whether they had learned Microsoft Excel or obtained related certifications prior to the experiment. Ten students reported that they had learned Microsoft Excel before. Therefore, their data were excluded from the analysis although these students remained in their original classes. Hence, 135 students who had not learned Microsoft Excel were regarded as participants with equal skill level.

In addition, a pretest that applied one-way analysis of variance (ANOVA) was conducted to assess students' academic motivation and school engagement before they received different teaching methods in this study. The results of the analysis revealed no significant difference among the four groups (see Table 1). That is, the pretest confirmed that, at the beginning of the experiment, the participants had average or little knowledge of the course content and equal levels of academic motivation and engagement.

Table 1 One-way ANOVA: pretest of students' academic motivation and engagement

Dependent variable	Group (I)	Group (J)	Mean difference ($I-J$)	SE	Sig.
Academic motivation	G1	G2	.02035	.18398	1.000
		G3	.18519	.17847	.783
		G4	.00367	.18526	1.000
	G2	G1	−.02035	.18398	1.000
		G3	.16484	.17078	.818
		G4	−.01668	.17786	1.000
	G3	G1	−.18519	.17847	.783
		G2	−.16484	.17078	.818
		G4	−.18152	.17216	.774
	G4	G1	−.00367	.18526	1.000
		G2	.01668	.17786	1.000
		G3	.18152	.17216	.774
Engagement	G1	G2	−.00459	.10971	1.000
		G3	.00954	.10642	1.000
		G4	−.09118	.11047	.877
	G2	G1	.00459	.10971	1.000
		G3	.01413	.10184	.999
		G4	−.08659	.10606	.881
	G3	G1	−.00954	.10642	1.000
		G2	−.01413	.10184	.999
		G4	−.10072	.10266	.810
	G4	G1	.09118	.11047	.877
		G2	.08659	.10606	.881
		G3	.10072	.10266	.810

4.2 Posttests

To explore the effects of ubiquitous SOL, the independent samples *t* test was used to compare the computing skills, academic motivation, and school engagement of the students in the SOL and non-SOL groups and in the LaD and non-LaD groups. The results, shown in Table 2, revealed no significant differences in students' grades for using Microsoft Excel between the SOL group and non-SOL group. Nevertheless, a significant difference was observed in students' computing skills between the LaD group and non-LaD group ($p < .01$). Because the average score in the LaD group (mean = 94.51) was significantly higher than that in non-LaD group (mean = 85.86), it was concluded that LaD is helpful for developing students' computing skills.

As shown in Table 3, no significant differences were observed in students' academic motivation between the SOL and non-SOL groups ($p = .553$) or between the LaD and non-LaD groups ($p = .888$). Therefore, neither SOL nor LaD led to the expected effects on the development of students' academic motivation in this study.

The results in Table 4 revealed no significant difference in students' engagement between the SOL group and non-SOL group ($p = .596$). In addition, no significant difference ($p = .212$) was observed in students' engagement between the LaD group and non-LaD group. Therefore, the expected effect of SOL and LaD on students' engagement was not found in this study.

Table 2 Comparison of students' computing skills

Computing skills	*N*	Mean	SD	*T*	*p*
SOL group (G1 + G2)	68	90.26	17.32	.229	.819
non-SOL group (G3 + G4)	67	89.52	20.20		
LaD group (G1 + G3)	63	94.51	9.07	2.879**	.005
non-LaD group (G2 + G4)	72	85.86	23.57		

**$p < .01$

Table 3 Comparison of students' academic motivation

Academic motivation	*N*	Mean	SD	*T*	*p*
SOL group (G1 + G2)	68	4.66	.957	−.594	.553
non-SOL group (G3 + G4)	67	4.74	.828		
LaD group (G1 + G3)	63	4.71	.862	.142	.888
non-LaD group (G2 + G4)	72	4.69	.925		

Table 4 Comparison of students' engagement

Engagement	N	Mean	SD	T	p
SOL group (G1 + G2)	68	3.70	.461	− .531	.596
non-SOL group (G3 + G4)	67	3.75	.506		
LaD group (G1 + G3)	63	3.67	.513	− 1.253	.212
non-LaD group (G2 + G4)	72	3.77	.452		

A number of previous studies indicate that motivation is an important factor [12, 57, 90, 106], and students' engagement is also a core element when implementing digital learning [9, 11, 41]. Although the expected effect of SOL and LaD on students' motivation and engagement was not found in this research, the potential reasons for the nonsignificant difference between groups are discussed in the following section.

5 Discussion and implications

The development of new technologies such as Web 2.0 and cloud computing has strongly attracted teachers' interest for their potential applications in education [31]. Online and cloud courses are innovative and evolving ways of offering educational opportunities, and teachers are still attempting to design effective online pedagogies and discover their new roles in online learning environments [91, 104]. Therefore, this study may contribute to online learning theory in three different ways. First, ubiquitous SOL was applied to help students to use computers, the Internet, and related technologies to develop their practical computing skills, academic motivation, and engagement in a cloud course. Second, ubiquitous LaD was adopted to improve students' attention and enhance their academic motivation and engagement in a computing course. Finally, this study may be one of the early attempts to integrate SOL and LaD with educational and ubiquitous technologies and to provide empirical measurement of the effects of SOL and LaD interventions on students' academic motivation and engagement. These contributions could inform educators who wish to design online or cloud courses.

5.1 Effects of self-organized learning

As shown in Tables 2, 3, and 4, in the SOL group, no significant difference was observed in students' computing skill ($p = .819$), academic motivation ($p = .553$), or engagement ($p = .596$) by the end of the semester. This result is similar to that of Clark [24], in which students' engagement did not significantly increase in an SOL learning environment. The nonsignificant differences may be because many students in Taiwan are familiar with following their teachers' learning arrangements and are unwilling or unable to take responsibility for their own learning [101]. They may not prefer to learn by themselves or with peers; instead, they may tend to have discussions with their teacher or follow their teacher's arrangement during the intervention to enhance their understanding [24].

It is revealed that SOL can be regarded as a learner-centered approach wherein learners have the responsibility for their own behavior; meanwhile they can also manage their own actions and directions via critical thinking reflection [26]. From the perspective of problem solving and learning, SOL promotes students to reach new levels of learning, and thereby cope with difficult situations [63]. Based on the findings in this study, the authors suggest that other researchers could adopt SOL and investigate its effect in ubiquitous or online courses in countries where students are typically more independent and actively engaged in their learning to obtain clear results.

Moreover, these nonsignificant results may have been influenced by the experiment time (one semester). That is, the short period might have been insufficient to reveal a causal relationship [60]. Therefore, teachers should design and implement SOL interventions for a longer duration to expand the effects of the experiment [24].

5.2 Effects of learners-as-designers

A shown in Table 2, in the LaD group, a significant difference was observed in students' computing skills by the end of the course ($p < .01$). This result is similar to that of Damnik et al. [28], Liu [68], indicating that instructional tasks such as designing a learning environment can produce enhanced learning outcomes. Damnik et al. [28] reported that adopting LaD tasks may help learners' to integrate information, which may also influence their learning behavior and knowledge acquisition. Thus, based on the findings presented in Table 2, the adoption of ubiquitous LaD may be beneficial for students' development of their computing skills.

Although ubiquitous LaD was found to improve students' development of better computing skills, the data in Tables 3 and 4 show no significant differences in students' academic motivation ($p = .888$) and engagement ($p = .212$) between LaD and non-LaD groups. Creating engaging and authentic design contexts for students is difficult within the confines of traditional schooling [1], even if the teacher adopts and integrates innovative teaching methods, such as SOL and LaD. For example, Shen et al. [95] indicated that the effects of innovative teaching methods in a one-semester course may be reduced because students' other courses still use traditional "spoon-feeding" teaching methods. It is suggested that other teachers in the same school or university should cooperate to help students to benefit from the innovative teaching methods and technologies.

5.3 Potential limitations of this study

Engaging academics in the use of technologies is a relatively recent priority in the higher education sector [13, 56]. Understanding students and their contexts is the key to designing effective learning methods and promoting the incorporation of new learning methods into practice [65]. A blended computing course was redesigned in the context of this study, to integrate SOL and LaD with educational technologies and u-learning, and the effects of SOL and LaD on students' motivation and engagement were investigated. A few limitations in drawing firm conclusions may be acknowledged, because of threats to the validity of conclusions drawn through the quasi-experimental design. Although pretests were conducted to measure students' computing skills and evaluate their motivation and engagement before the experiment began, problems with this quasi-experimental design may exist. For example, students' personal characteristics and their readiness for online learning and using technology devices may differ among the four groups, thus causing measurement bias.

Moreover, because students in a comparison group may have been more motivated than those in the control group, issues with the experimental validity may exist [40]. Thus, these contextual factors may affect and compromise the validity of the results. Finally, although the ten students who had experience in using Microsoft Excel before this course were excluded from the analysis, they still stayed and learned in their original courses. Since these are real courses, it was not possible to stop them interacting with others. They may potentially interact with other students as they learn in the u-learning environment, and influence others' learning. Thus, the authors checked the potential influence from the ten students by adding them to our original data, and analyzing it again. This yielded the same results as reported in Sect. 4. Nevertheless, it is still suggested that researchers and educators who apply ubiquitous SOL and LaD should be aware of individual differences and the potential factors of quasi-experimental design that can influence research findings.

6 Conclusion

Due to the development of and reliable access to robust technologies, most university courses are moving toward some form of blended learning [43]. Educational technology and learning management systems are usually centered on one specific institution or course; although they are useful tools for teachers, course designers, and human resource managers in companies, they cater more to their needs than to those of learners [37]. Along with the development of educational technologies, teachers should also develop appropriate pedagogies to improve their students' learning in online learning environments [101]. Therefore, the researchers in this study reflected on previous teaching in computing courses and designed appropriate teaching methods of ubiquitous SOL and LaD in a cloud classroom, to explore their effects on the enhancing students' learning performance, academic motivation, and engagement.

The findings of this study revealed that the students who received LaD intervention in a u-learning environment had significantly enhanced computing skills compared with the skills of those who did not receive the intervention. However, the students who received the ubiquitous SOL approach did not show significantly improved computing skills, a higher level of academic motivation, or greater engagement in the computing course. These results regarding the implementation of SOL and LaD in a u-learning environment can provide comprehensive insights for online instructors who wish to apply these teaching approaches to assist students develop practical and high-level computing skills, achieve academic motivation, and become engaged in blended learning environments, particularly for computing courses.

Appendix

See Table 5.

Table 5 Results of pre- and posttests per student

Student no.	Academic motivation			Engagement			Computing skill
	Pretest	Posttest	Diff.	Pretest	Posttest	Diff.	Score
1	4.19	4.61	0.42	3.42	3.53	0.11	91
2	3	4.94	1.94	3.32	4.32	1	100
3	4.03	4.35	0.32	3.26	3.68	0.42	54
4	3.97	5.23	1.26	3.21	3.63	0.42	100
5	3.9	4.48	0.58	3.11	3.58	0.47	90
6	4.45	6.81	2.36	3.84	5.11	1.27	100
7	6.23	1.81	−4.42	3.84	4.05	0.21	100
8	5.13	4.68	−0.45	3.47	3.63	0.16	100
9	3.71	4.03	0.32	3.11	3.32	0.21	71
10	5.26	5.81	0.55	3.79	3.68	−0.11	100
11	3.68	3.9	0.22	3.21	3.84	0.63	84
12	5.16	6.32	1.16	3.53	4.05	0.52	100
13	3.77	4	0.23	3.26	3.58	0.32	84
14	4.06	4.35	0.29	2.11	3.53	1.42	100
15	4.42	5.68	1.26	3.47	3.84	0.37	77
16	3.87	4.58	0.71	3.63	3.74	0.11	98
17	4.48	4.39	−0.09	3.74	3.68	−0.06	57
18	2.61	2.87	0.26	3.42	2.74	−0.68	89
19	2.9	4.68	1.78	2.74	3.47	0.73	100
20	4.29	5.65	1.36	3.42	4.21	0.79	52
21	5.06	5.81	0.75	3.63	4	0.37	90
22	5.16	4.16	−1	2.79	3.47	0.68	94
23	4.35	4.81	0.46	3.42	3.63	0.21	90
24	2.16	3.35	1.19	2.74	3.32	0.58	100
25	4.39	4.19	−0.2	3.47	3.58	0.11	0
26	4.52	5.32	0.8	3.26	3.37	0.11	97
27	4.97	5.35	0.38	3.74	4.05	0.31	100
28	3.39	4.58	1.19	3.32	3.95	0.63	100
29	3.71	3.97	0.26	3.05	3.26	0.21	100
30	4.45	5.29	0.84	2.53	2.95	0.42	100
31	4.58	5.13	0.55	3.11	3.95	0.84	89
32	3.68	2.65	−1.03	3.74	3.89	0.15	84
33	3.94	4.9	0.96	3.68	4	0.32	85
34	2.48	2.97	0.49	2.68	2.58	−0.1	97
35	3.9	4	0.1	2.68	3.32	0.64	100
36	6.29	5.71	−0.58	4.63	4.37	−0.26	100
37	3.97	4.19	0.22	2.95	3.42	0.47	53
38	3.74	4.03	0.29	2.89	3.37	0.48	100
39	5.61	5.65	0.04	4.16	4.21	0.05	43
40	4.58	4.77	0.19	3.89	3.68	−0.21	98
41	3.39	4	0.61	2.32	3.32	1	100
42	4.65	5.45	0.8	2.95	3.74	0.79	100
43	4.13	2.48	−1.65	2.89	3.79	0.9	100
44	3.74	4.32	0.58	2.68	3	0.32	100
45	4.1	4	−0.1	4.53	4	−0.53	39
46	4.52	5.32	0.8	3.63	3.89	0.26	91
47	5.03	5.74	0.71	3.95	4.26	0.31	85
48	4.23	5.19	0.96	3.58	4.37	0.79	85
49	4.32	5.23	0.91	3.32	3.58	0.26	100

Table 5 (continued)

Student no.	Academic motivation			Engagement			Computing skill
	Pretest	Posttest	Diff.	Pretest	Posttest	Diff.	Score
50	4	4.68	0.68	3.42	4	0.58	96
51	3.9	3.74	−0.16	3.47	3.68	0.21	86
52	4.65	5.13	0.48	2.79	3.42	0.63	94
53	4.39	6.03	1.64	3.63	4.26	0.63	85
54	4.81	4.9	0.09	3.05	3.63	0.58	94
55	4.94	5.45	0.51	3.84	4.37	0.53	100
56	4.32	4.94	0.62	3.47	3.95	0.48	92
57	4.35	5.39	1.04	3.84	4.42	0.58	100
58	5.45	5.1	−0.35	3.84	3.63	−0.21	36
59	4.32	3.97	−0.35	3.42	3.68	0.26	100
60	4	4.68	0.68	3.47	3.95	0.48	97
61	4.13	4.1	−0.03	3.37	3.74	0.37	97
62	4.39	6	1.61	3.74	4.68	0.94	100
63	4.35	4.84	0.49	3.42	3.63	0.21	100
64	4.32	4.61	0.29	3.37	3.68	0.31	100
65	4.74	4.58	−0.16	3.26	3.58	0.32	91
66	3.68	4	0.32	2.26	3.32	1.06	12
67	4.32	6.03	1.71	2.84	4.68	1.84	56
68	3.68	5.97	2.29	3.74	4.68	0.94	0
69	3.97	4	0.03	3.53	3.32	−0.21	98
70	5.65	5.19	−0.46	4.05	4.37	0.32	81
71	5.06	4.87	−0.19	3.58	4	0.42	100
72	4.23	3.81	−0.42	3.63	3.53	−0.1	100
73	3.94	4.71	0.77	3.21	3.89	0.68	94
74	5.97	6.03	0.06	4.16	4.68	0.52	96
75	4.45	4.68	0.23	3.26	4.05	0.79	100
76	4.29	4.65	0.36	3	3.26	0.26	91
77	3.97	4.42	0.45	3.05	3.74	0.69	100
78	5.71	6.19	0.48	4.63	4.74	0.11	100
79	4.58	4.97	0.39	3.05	3.63	0.58	94
80	4.1	4.35	0.25	3.47	3.68	0.21	100
81	4.16	5.68	1.52	3.32	4	0.68	93
82	4.35	4.68	0.33	3.68	3.47	−0.21	94
83	3.84	5	1.16	3.16	3.42	0.26	100
84	3.94	3.68	−0.26	3.84	4.26	0.42	100
85	3.68	4	0.32	3	3.32	0.32	79
86	4.68	4.13	−0.55	3.37	3.47	0.1	100
87	4.23	4.42	0.19	3.16	3.74	0.58	79
88	5.48	5.35	−0.13	3.68	3.89	0.21	90
89	3.68	4.39	0.71	3	3.42	0.42	51
90	3.81	4.29	0.48	2.95	3.32	0.37	100
91	4.97	4.16	−0.81	3.11	3.32	0.21	100
92	3.68	4	0.32	3.21	3.26	0.05	100
93	3.71	4.71	1	3.32	3.58	0.26	97
94	4.52	4.65	0.13	3.68	3.63	−0.05	100
95	3.94	4.16	0.22	3.32	3.32	0	98
96	5	5.48	0.48	3.42	3.74	0.32	100
97	3.45	6.06	2.61	2.89	3.53	0.64	94
98	5.35	5.81	0.46	3.63	4.05	0.42	100

Table 5 (continued)

Student no.	Academic motivation			Engagement			Computing skill
	Pretest	Posttest	Diff.	Pretest	Posttest	Diff.	Score
99	3.9	4	0.1	3.11	3.32	0.21	100
100	3.84	4.52	0.68	3.05	3.42	0.37	64
101	4.61	5.61	1	2.95	3.11	0.16	93
102	3.68	4	0.32	3.05	3.32	0.27	100
103	4.32	6.13	1.81	3.11	5.11	2	100
104	4.39	1.97	−2.42	3.58	1.95	−1.63	97
105	3.87	4	0.13	3.11	3.32	0.21	92
106	6.06	4.68	−1.38	3.74	3.32	−0.42	89
107	6.1	6.23	0.13	2.74	3.53	0.79	100
108	5.32	5.81	0.49	3.74	4.05	0.31	100
109	4	4.74	0.74	3.37	3.79	0.42	85
110	3.68	4	0.32	3	3.32	0.32	100
111	4.23	5.06	0.83	3.37	3.84	0.47	100
112	4.26	5.68	1.42	3.58	4.47	0.89	100
113	4.71	4.9	0.19	3.32	3.79	0.47	96
114	3.87	4.1	0.23	3	3	0	94
115	3.68	4	0.32	3	3.32	0.32	82
116	3.97	5.58	1.61	3.74	3.95	0.21	100
117	4.97	5.29	0.32	3.47	4	0.53	93
118	3.84	5.19	1.35	3.42	3.89	0.47	100
119	3.68	4.68	1	3	4.05	1.05	94
120	6.03	6.03	0	4.37	4.68	0.31	91
121	3.81	4.39	0.58	3.16	3.58	0.42	100
122	3.65	4.23	0.58	3.16	3.79	0.63	98
123	4.03	4.1	0.07	3.21	3.32	0.11	100
124	3.94	4.48	0.54	3	3.11	0.11	73
125	4.23	4.32	0.09	2.79	3.26	0.47	94
126	5.52	6.03	0.51	3.68	4.68	1	100
127	4.19	4.68	0.49	3.11	4	0.89	100
128	4.52	5.23	0.71	3.58	3.79	0.21	97
129	4.58	4	−0.58	3.21	3.79	0.58	100
130	5.35	1.81	−3.54	3.68	2.63	−1.05	94
131	3.68	4.68	1	3	3.32	0.32	94
132	4.35	4.68	0.33	3.68	4	0.32	100
133	4.1	4.71	0.61	3.32	3.84	0.52	96
134	4.94	4.77	−0.17	3.79	3.89	0.1	88
135	3.74	3.97	0.23	3	3.26	0.26	100
Aggregate	Sum diff		51.75	Sum diff		51.05	12136
	Mean diff		0.38	Mean diff		0.38	89.90

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