Universal Access in the Information Society (2020) 19:783–798
https://doi.org/10.1007/s10209-019-00690-x

LONG PAPER

Exploring the effects of web-mediated activity-based learning and meaningful learning on improving students' learning effects, learning engagement, and academic motivation

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Published online: 19 September 2019

Abstract
The application and development of educational technologies has influenced current education practices. However, there are few studies discussing how to apply these technologies and devices with appropriate teaching methods to help students achieve satisfactory learning goals, especially for computing classes. Thus, the researchers reconsidered the course design of a computing course with practical teaching methods, activity-based learning (ABL) and meaningful learning (ML), in an online learning environment. The researchers investigated, via quasi-experiments, the effects of web-mediated ABL and ML on developing students' learning effects, learning engagement, and academic motivation in this online computing course. A 2 (ABL vs. non-ABL) × 2 (ML vs. non-ML) design, as well as factorial pretest/posttest design, was employed in this experimental research. The selected course for experiment was titled "Applied Information Technology: Office Software," one semester in length and a required course for the four involved classes of students at a comprehensive university. All students in this study came from non-computer departments. According to the results of this study, students who received web-mediated ML had a significant increase in their learning engagement. However, the expected effects of ABL on developing students' skills in using PowerPoint and Word, learning engagement, and academic motivation were not found in this study. Possible explanations for this nonsignificant outcome are included in the paper. The researchers' design of an online course integrating ABL and ML may be used by teachers and schools when conducting online, flipped, or blended courses for their students, particularly for those courses focused on developing students' skills in using PowerPoint and Word.

Keywords Web-mediated activity-based learning · Web-mediated meaningful learning · Online education · Skills in using PowerPoint and Word · Learning engagement · Academic motivation

1 Introduction

The application of educational technology in everyday life has become a trend in learning [14]. The development of information and communications technologies (ICT) has affected modern education. The main purpose of adopting and integrating educational technologies into the learning environment is to improve the quality and facilitate the success of education [92]. Technology has come a long way from merely being an instrument of distributing knowledge, to becoming an essential part of shaping the "anywhere at any time" e-learning environments [42, 51].

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Moreover, the increasing demand for computing and programming courses has led many universities to design and apply online environments to deliver these courses. The attributes of educational technologies and pedagogies play critical roles in the effectiveness of such computing courses [10]. However, there are few studies discussing how to apply educational technologies or mobile devices and design appropriate teaching methods to help students develop skills in using PowerPoint and Word [123]. Therefore, the researchers in this study integrated appropriate teaching methods with educational technologies, as based on the characteristics of computing courses and students' needs, and our reflections from previous teaching in computing courses for more than 10 years, which are described in section "1.1. The Importance of Activity-Based Learning for Graduates" and "1.2. The Importance of Meaningful Learning in Online Courses."

1.1 The importance of activity-based learning for graduates

As modern people use computers and the Internet daily in their workplaces, computing skills are one of the critical factors that attract a premium in the labor market [41]. With the very rapid development of information technologies, the demand and requirements for knowledge and various computing skills in business and social activities are growing [59]. In a software-driven world with growing demands for Information and Communication Technologies (ICT) professionals [37, 38], the challenge of training students to be more efficient in computer-based society becomes a new focus for educators. Moreover, it is also indicated that computing skills and knowledge are regarded as a general competence in the curriculum [84]. Other researchers have also mentioned the pressing needs of preparing the young generation to be familiar with not only the ways of utilizing computer tools, but also the rules of digital languages and computational thinking [71]. For example, courses in application software and computational thinking are emphasized for students of all disciplines in Taiwan [123].

Although the importance of students' skills in using PowerPoint and Word in the workplace is clear, they may not be prepared to capably solve problems from what they have learned at school [118]. For example, it is reported that many graduates felt that they did not have adequate practical skills and knowledge needed in the workplace [32]. Moreover, it is also revealed that many employers complain that while graduates have theoretical knowledge they lack the practical skills and knowledge required in the marketplace [108]. According to Halpern [46] and Hood and Littlejohn [50], activity-based learning (ABL) is regarded as one of the fitting strategies and solutions to nurture students' computing skills in a practical manner. ABL is a learning process that engages students in learning activity and promotes them to reflect upon ideas and how to adopt these ideas [63]. An example of activity-based strategy is one that uses "hands-on" interactions with objects during a counting activity [5]. Students can then construct knowledge by seeking new information from instructions and experiences to create meaning [54]. In order to absorb the learning material, learners have to actively engage with it [113].

Based on the theory of connectivism, knowledge can be generated by learners' discussion and experience sharing [13]. ABL offers learners an avenue to integrate learning within students' knowledge and activities to provide an effective educational experience [74]. Moreover, it is also reported that utilizing a variety of activities in teaching can not only engage students but also provide multiple access points into learning and support knowledge construction [87]. Furthermore, the existing research indicates that teaching methods can be changed not only by providing the infrastructure and technological hardware [17, 105], but also the technology can be leveraged to facilitate constructivist teaching reform [72, 76, 104]. Thus, the researchers in this study adopted ABL in a technology-supported course and investigated its effects on improving students' learning effects, learning engagement, and academic motivation.

1.2 The importance of meaningful learning in online courses

In higher education, teachers and students have experienced significant developments in online learning [116], and the demand for online courses is increasing almost exponentially [109]. However, in technology-based learning environments, it is difficult to involve students or help them concentrate on coursework because social networking web sites, shopping web sites, and free online games are also within reach in the same environment [15, 117]. Moreover, it is also observed that many students use their smart phones and laptops in traditional classrooms for watching videos and browsing social networking web sites; thus, teachers may wonder whether their students can concentrate on online or blended courses without teachers' on-the-spot attention. Thus, online teachers should consider adopting or integrating innovative teaching methods to help students focus on and benefit from online courses [120].

As previous studies have indicated the problems of students' high dropout rates from online courses [73, 119], meaningful learning (ML) may be one of the potential solutions to concentrate students' attention on their online learning behavior and address the dropout rate issue. ML is a kind of teaching strategy which allows traditional curriculum to be tuned to the learner's willingness to actively and positively engage in learning to improve learning outcome [28]. ML occurs when students receive the knowledge and activate the cognitive processes needed for successful problem-solving [111], and has been regarded as a learning process that helps students gain a deeper understanding of learning objectives [40, 56, 60, 62].

In order to improve students' learning effects, learning engagement, and academic motivation in computing courses, the researchers in this study applied ML in the involved computing course. The existing research reports that learning with computers involves establishing an intellectual partnership with computers to enhance ML [61, 65]. Moreover, it is described that good teaching includes facilitating student learning by applying educational technology and resources as meaningful pedagogical tools [25, 72]. Thus, ML was adopted and integrated into a computing course with educational technologies, and its effects on developing students' skills in using PowerPoint and Word, learning engagement, and academic motivation were investigated in this research.

Recent technological developments in telecommunications, including the Internet, have brought about more online applications [22]. The use of the Internet with educational technologies in university education has grown at an exponential rate [4, 91]. In addition, it is also reported that recent government moves in many nations have seen coding included in school curricula, or promoted as part of computing, or science courses [27]. Researchers such as Viberg et al. [127] and Murthy et al. [88] mention the integration of digital technologies and the challenges as well as the expectations that educators face. Thus, both technology requirements and learner needs are the drivers of this study. However, there are few studies discussing practical and effective online pedagogies integrated with related technologies for teachers and students [118, 123]. In this regard, the researchers in this study redesigned a computing course by refining web-mediated teaching pedagogies based on the course orientation and students' needs for practical computing skills and empirically evaluated students' learning effects, learning engagement, and academic motivation in this course.

2 Literature review

2.1 Learning effects

Learning effects are defined as the extent to which a student is making progress in learning, to achieve her/his educational goals, in terms of added knowledge and skill building during education [22]. In the computing course involved in this study, the teaching mainly concentrated on enhancing students' skills in using Microsoft Word and PowerPoint; the students were required to pass the examinations for related certificates. It is described that helping students develop their skills in using PowerPoint and Word and passing the examinations for related certificates is the main concern of many teachers of computing courses in Taiwan [120]. Thus, in this computing course, students' skills in using PowerPoint and Word, as demonstrated by passing the certification exams, were regarded as the learning effects in this study.

2.2 Students' learning engagement

Learning engagement is regarded as the collection of goal-directed behaviors and reflections demonstrated to indicate a deep and meaningful involvement in students' learning activities [64]. Many studies have found that learning engagement plays a critical role in improving educational effectiveness [33, 75, 110]. In addition, it is reported that students' learning engagement is not only emphasized in traditional teaching approaches, it is also connected to educational technologies and digital media [132].

Given the opportunity, an engaged student would initiate, persist, and/or concentrate on mastering and applying newly learned skills or knowledge, resort to deep approaches for problem-solving, and also demonstrate positive attitudes toward her/his learning process [18, 64, 85]. Developing models and measures of the factors that facilitate students' learning engagement is critical to the advancement of the field of education [47]. Thus, the researchers in this study investigated whether students' learning engagement was enhanced in the implementation of web-mediated ABL and ML.

2.3 Academic motivation

Academic motivation is an internal power which leads students to an overall evaluation of performance according to the highest criteria, to make effort to succeed, and to experience the joy of successful outcomes [21, 31]. It is a critical concept in education and also a pivotal condition for success that fosters learners' actions to perform activities essential for learning [126]. However, existing research describes that many students show poor academic motivation [81]. Thus, it is necessary for educators to develop students' academic motivation, including in the online or blended learning environments.

One of the keys to effective educational investment in any society is students' academic motivation [86]. Academic motivation is of great interest and an important factor in education as it conceptually determines the role of learners' behavior and preparation results [24]. Nevertheless, the literature about the dynamic nature of teachers' instruction and how it relates to students' development of academic motivation is limited [81]. In this regard, the researchers in this study strove to demonstrate whether students' academic motivation in a blended computing course is elevated after they receive the treatment of web-mediated ABL and ML.

2.4 Activity-based learning

ABL is the process of learning through completing an activity and can be helpful in narrowing or bridging the gap between theory and practice [95]. It is considered as a type of constructivist learning [48, 74] which utilizes both collaborative interaction and accessing information-rich resources [78] and encourages learners to interact with their environment [5]. The existing research indicates that an ABL environment, which may require more active engagement and additional effort by students, universally results in positive student learning effects [45].

ABL and interventions incorporating theory could lead to learners' development in critical appraisal ability, research knowledge, and research self-efficacy [43, 49]. In an ABL environment, the activity may involve understanding theoretical concepts and/or the use of technology [112]; it may comprise individual or teamwork tasks, role-playing, simulation, games, and even a combination of two or more of the above [79, 113]. ABL could engage learners more aggressively in studying than is typical in traditional, didactic education [26, 83], as well as facilitate students' thinking so as to foster specific types of learning, knowledge construction, and retention [63]. Additionally, it is indicated that teachers who adopt ABL can not only deliver academic lessons, skills and competencies, and personal lessons, but also support learners' knowledge building and problem-solving skills [54].

As for the potential effects of ABL in online learning environments, its student-centric and activity-based nature could lead to students taking responsibility for their learning process [98]. ABL is one of the factors that help in mapping the evolving e-learning landscape [89]. It is suggested that an effective combination of both physical and computer-based activities may provide a better learning environment for students [112]. Modern students may adapt to traditional learning, but gravitate toward ABL, as it facilitates theory application and provides some type of "instant gratification" [2, 3]. However, as it is indicated that, in the case of online students, ABL may not be as effective as expected [46], the researchers in this study explored the effects of ABL on improving students' learning effects, engagement, and academic motivation in an online computing course.

Therefore, the first research question (RQ) in this study is:

RQ1 Does web-mediated ABL lead to better development of students' learning effects, learning engagement, and academic motivation in an online computing course?

2.5 Meaningful learning

ML is an active process that inspires a deeper and broader understanding and learning of concepts. This results from the interaction between new and previous knowledge resulting in enduring development of students' knowledge and skills [9]. The ML framework serves as the foundation for practice-oriented pedagogical models for different educational purposes [44, 67, 129]. ML takes place when learners develop knowledge in response to their prior knowledge or previous experiences in ways that can reflect on the learning activity and reveal what they have learned [30, 122].

Formative and summative assessments lead to ML when more cognitive processes and complex knowledge are assessed [6]. Through individual or group explorations and integration of new knowledge with relevant prior knowledge, students can make their learning experience meaningful [82, 90, 111]. Adopting ML strategy can not only improve users' learning motivation but also reduce the cognitive load, and even promote their learning achievement [29]. That is, ML is considered an effective teaching method [30, 39, 122], wherein teachers could reinforce their teaching strategies with meaningful instructional activity contents to spark students' learning potential [28].

With regard to the effects of ML in an online course or computer-based learning program, it is found that students who used a computer-based simulation program were more likely to report ML themes than those who received the same content through a lecture method [97]. In addition, it is also reported that there are positive correlations between ML and learning outcomes [28, 94]. However, there are very few studies that explore the effects of ML in an online or blended computing course. Thus, the researchers in this study adopted ML and investigated the effects of ML on developing students' learning, engagement, and academic motivation in an online computing course.

Therefore, the second research question in this study is:

RQ2 Does web-mediated ML lead to better development of students' learning effects, learning engagement, and academic motivation in an online computing course?

3 Method

3.1 Participants

The participants in this study were four classes of first-year students taking a compulsory course titled "Applied Information Technology: Office Software." Students were divided into the ABL and ML class (C1, $n=49$), the ABL and non-ML class (C2, $n=37$), the non-ABL and ML class (C3, $n=42$), and the non-ABL and non-ML class (C4, control group, $n=35$), and all came from the Department of Finance at a comprehensive university. That is to say, all involved participants from a non-information and non-computer department and were generally not able to use application software proficiently. The teacher in these four classes was the same, and all subjects were requested to use the same course web site which was based on Moodle, an open-source learning management system. The experimental design and hypothesized results of the four groups are shown in Fig. 1.

Before the course started, the teacher declared that this involved class would be provided through Internet and the classroom, and students in the four classes would receive teacher's treatments of different teaching methods in an experiment. In addition, the teacher also announced that

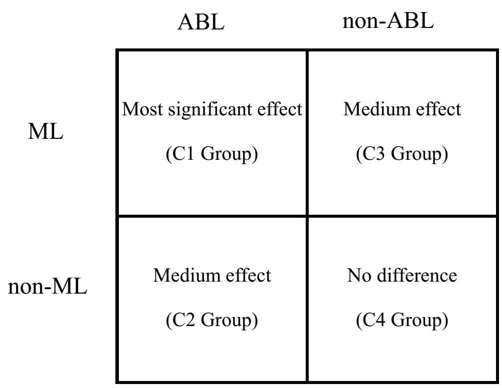


Fig. 1 Experimental design for this research

students from the four classes had the right and freedom to drop and select another teacher's course, if they did not want to stay in this experiment.

3.2 Course setting

Based on subject matter, some courses are more suitable for learning by doing—or ABL—than others, with technology-related classes typically being good candidates because of the focus on developing practical skills and knowledge [99]. Thus, the course involved was a semester-long, two-credit-hour computing course titled "Applied Information Technology: Office Software." This course focuses mainly on developing students' skills in using Microsoft Word and PowerPoint. In addition, students in this course are required to pass the examinations for related certificates. In the teaching of this course, the teacher first introduced the basic functions of Word and PowerPoint. Then, the teacher applied the designed activities of ABL and ML described in subsections "3.3.1. Treatment of ABL" and "3.3.2. Treatment of ML" in the three experimental groups.

3.3 Experimental design and procedure

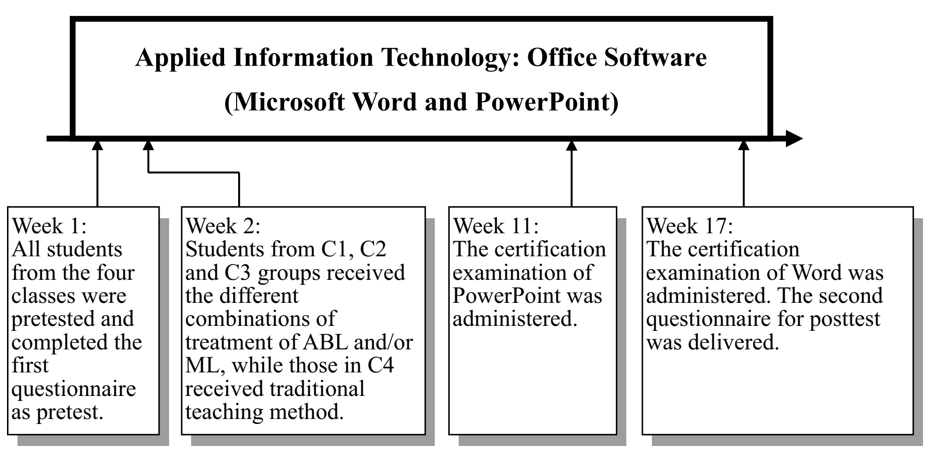
The researchers explored the outcomes of ABL and ML on developing students' learning effects, engagement, and academic motivation. The experimental design was a 2 (ABL vs. non-ABL) × 2 (ML vs. non-ML) factorial pretest/posttest design, and four classes (groups) were involved in this experiment. The first class (C1) simultaneously received the treatment of web-mediated ABL and ML, the second class (C2) received the treatment of web-mediated ABL only, and the third class (C3) received the treatment of web-mediated ML only, while the last group (C4) received the traditional teaching method as the control group. The schedule of the course experiment is illustrated in Fig. 2.

3.3.1 The treatment of ABL

The purpose of ABL is to guide students to regularly evaluate their learning performance in a particular discipline [63]. The activity may involve understanding theoretical concepts and/or the use of technology [112] and comprises individual or team work, role-playing, simulation, games, and combinations of two or more of the above [79, 113]. The integration of learning activities links various kinds of tasks which are experienced at different stages. The integrated approach is regarded as supporting students in development of their knowledge and skills [112].

Moreover, the existing research indicates that if the course is designed around learning activities, it is important for students to immerse in these activities to engage with the learning process and benefit from the course [78, 124]. In the involved course, each week of the semester, students were required to solve problems using the computing skills they had just learned. In the problem-solving processes and the implementation of ABL in C1 and C2, the researchers adopted Fallon, Walsh et al.'s [26] processes to help students immerse in the activities, such as: (1) students would work four or five in each group; (2) the activities would be

Fig. 2 Proposed schedule of the course and certification examinations during the semester



completed within the two-hour class session; (3) every group had to propose some ideas and these would be used to give a context for later activities; (4) team work would be submitted to the teacher at the end of each session and feedback would be provided the following week.

Furthermore, the researchers also provided additional help for students through the establishment of online discussion groups where quick feedback is offered to students. Students were encouraged to discuss thoughts and questions on this online platform. Once students submitted queries, the teacher would answer their questions in a short time. This additional support has been shown to not only help students' learning, but also provide information for the teacher and researchers, revealing troubles and confusions encountered by students [112].

3.3.2 The treatment of ML

In meaningful instruction strategies, teachers play the role of constructing and guiding learning activities, assisting in team cooperation, and interpreting materials; thus, they have to design creative lessons, construct adaptive learning materials, plan staged materials clearly to be systematic, as well as guide and concisely interpret learning progress for students [28]. Moreover, ML requires instructor guidance to mediate tool or technology use and coordinate students' activities via scaffolds [8, 80, 93]. The researchers designed this computing course with learning materials and educational technologies for students' ML before the course began.

In order to be meaningful, learning should also be contextualized [77]. The most important element of ML is not how to present the learning materials, but how these new learning materials are integrated into learners' existing knowledge base [65]. Meaningful scaffolding through learning activities can improve the learning effects of students [53, 57, 58, 66, 101]. As ML is regarded as the process through which learners connect new information received with their previous knowledge or personal past experiences [58, 100, 128], in the teaching and treatment of ML, the researchers linked students' newly learned skills with their past experiences to help boost their involvement in the simulated problems, situations, and scaffolding.

Furthermore, Howland et al. [52] point out five dimensions that characterize how ICT could support ML, including: (1) active—learners are not passive listeners but aggressively implement objects and information, and observe results; (2) constructive—learners construct knowledge, reflect, and illustrate their personal understandings of phenomenon; (3) authentic—learners engage in solving real world problems; (4) intentional—learners set their own goals and plan the learning process; and (5) cooperative—learners study with peers [11, 68]. These dimensions were also considered and adopted in the treatment of ML in this study, to help students benefit from the implementation of ML with related technologies.

3.4 Evaluation

3.4.1 Pretests of students' skills in using PowerPoint and Word, learning engagement, and academic motivation

3.4.1.1 Computing skills In order to prevent the factors from students' initial differences in computing skills to cause potential bias in measuring students' learning, at the beginning of the experiment, the researchers checked and confirmed students' level of skills in Microsoft Word and PowerPoint before they received the treatments of web-mediated ABL or ML. Also in the first week, the teacher verified who had previous learning experience or had passed the certificate examinations of Word and PowerPoint before they took this course. Students who had previously learned or passed the certificate examinations were excluded from the experiment, although they still stayed and learned in this course.

3.4.1.2 Learning engagement The researchers measured students' learning engagement and checked whether the groups of students had similar levels of learning engagement before the experiment began. Students of the four classes were requested to finish the School Engagement Scale, created by Fredricks et al. [34] to serve as a pretest of their learning engagement. The School Engagement Scale is a 19-item instrument, divided into three types: (1) behavioral engagement; (2) emotional engagement; and (3) cognitive engagement. Students were required to rate themselves on a five-point Likert scale, from 1 (Strongly disagree) to 5 (Strongly agree). Then, the researchers tested whether there was any difference in students' learning engagement within the four groups before they received the treatment of web-mediated ABL and/or ML.

3.4.1.3 Academic motivation The subjects in the four groups were also required to complete the motivation section of the Motivated Strategies for Learning Questionnaire (MSLQ) created by Pintrich et al. [96] as a pretest of students' academic motivation before the course began. MSLQ is one of the most widely used instruments for evaluating students' academic motivation and learning strategies [12, 20]. It is an 81-item, self-report instrument, divided into two broad categories: (1) a motivation section that consists of 31 items and (2) a learning strategies section that includes 50 items. In this research, the 31-item motivation section was adopted as the pretest. Students rated themselves on a seven-point Likert scale, from 1 (not at all true of me) to 7 (very true of me). The researchers tested whether any dissimilarity of students' motivation existed among the four groups at the beginning of the experiment.

3.4.2 Posttests of students' skills in using PowerPoint and Word, learning engagement, and academic motivation

3.4.2.1 Computing skills All students from the four groups were required to take two examinations for certificates in Microsoft PowerPoint (week eleven) and Word (week seventeen). These certificate examinations were administered by Computer Skills Foundation, a renowned and trustworthy organization in Taiwan. There are two problems on the PowerPoint examination and three problems on the Word examination, which each consist of 5–8 sub-problems. Before the examinations, students were assigned random seats. They had 40 minutes to complete each examination. After the examinations, the researchers investigated the skills' differences among the four groups of students in using Microsoft PowerPoint and Word.

3.4.2.2 Learning engagement The questionnaire for measuring students' learning engagement in the posttest was the same with that in the pretest of this study. All told, students from the four groups completed the School Engagement Scale developed by Fredricks et al. [34] twice. The posttest was administered in the seventeenth week, and then, the differences in students' learning engagement between the different groups were analyzed and tested. In addition, the development of their learning engagement from start to finish of the semester was also checked in this study.

3.4.2.3 Academic motivation In this research, the evaluation of students' academic motivation in the posttest was the same with that in the pretest. All participants from the four groups completed the motivation section of MSLQ a second time in the seventeenth week of the semester. After the posttest, the differences in students' academic motivation among the four groups were analyzed and reported. Moreover, the development of students' motivation over the whole semester was investigated in this study.

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

Dependent variable	Group (I)	Group (J)	Mean difference (I − J)	SE	Sig.
Engagement	C1	C2	0.11072	0.08888	0.67094
		C3	0.11475	0.08581	0.61844
		C4	0.04984	0.09031	0.95905
	C2	C1	−0.11072	0.08888	0.67094
		C3	0.00403	0.09201	0.99998
		C4	−0.06088	0.09622	0.94001
	C3	C1	−0.11475	0.08581	0.61844
		C2	−0.00403	0.09201	0.99998
		C4	−0.06491	0.09339	0.92242
	C4	C1	−0.04984	0.09031	0.95905
		C2	0.06088	0.09622	0.94001
		C3	0.06491	0.09339	0.92242
Motivation	C1	C2	0.21865	0.12729	0.40208
		C3	0.15953	0.12289	0.64104
		C4	0.21791	0.12934	0.41988
	C2	C1	−0.21865	0.12729	0.40208
		C3	−0.05912	0.13177	0.97730
		C4	−0.00075	0.13781	1.00000
	C3	C1	−0.15953	0.12289	0.64104
		C2	0.05912	0.13177	0.97730
		C4	0.05837	0.13376	0.97904
	C4	C1	−0.21791	0.12934	0.41988
		C2	0.00075	0.13781	1.00000
		C3	−0.05837	0.13376	0.97904

4 Results

4.1 Pretests

To avoid measurement bias due to students' initial differences, the researchers in this study measured students' learning engagement and academic motivation before the experiment began. Based on the pretests given in Table 1, the difference in students' learning engagement and academic motivation among C1, C2, C3, and C4 are not statistically significant. Furthermore, the authors also verified students' computing skills of using Microsoft Word and PowerPoint before the course started. In the first week of the semester, the teacher checked whether students had previous learning experience in Microsoft Word and PowerPoint. Students who already acquired both Microsoft Word and PowerPoint skills were excluded from the experimental sample, although they still remained in this course.

Based on the pretest analysis and teacher's confirmation, the authors in this study could confirm that the participants had similar levels regarding skills in using PowerPoint and Word, learning engagement and academic motivation when the program initiated. For that reason, the hidden concerns of initial variance among students' skills in using PowerPoint and Word, learning engagement, and academic motivation can be eliminated.

4.2 Posttests

4.2.1 Effects of activity-based learning

To explore the effects of web-mediated ABL and to answer RQ1, the independent samples *t* test was used to investigate and compare students' learning engagement, academic motivation, and skills in using PowerPoint and Word between ABL group (C1 + C2) and non-ABL group (C3 + C4). In this study, there were no significant differences in students' skills in using PowerPoint and Word, learning engagement, or academic motivation between ABL and non-ABL groups ($p > 0.05$). These results exhibit that the treatment of web-mediated ABL did not distinctly impact students.

In this study, the paired samples *t*-test was applied to compare students' engagement in this online computing course. As the results disclosed in Tables 3 and 4 show, it is found that the ABL group had a significant increase in their learning engagement at the end of the semester (mean = 3.4786) in contrast to their pretest (mean = 3.3917) ($p < 0.05$). However, the non-ABL group also showed a significant increase in learning engagement with posttest (mean = 3.4409) in contrast to their pretest (mean = 3.3541) ($p < 0.05$). That said, students who received the treatment of ABL did exhibit better development of learning engagement than those did not receive ABL.

In addition, it is also found that the ABL group showed a significant increase in their academic motivation at the end of the semester (mean = 4.7881), in contrast to their pretest (mean = 4.5570) ($p < 0.001$). Moreover, the non-ABL group also showed a significant increase in academic motivation with posttest (mean = 4.7168) in contrast to their pretest (mean = 4.4650) ($p < 0.01$). This means that students who received the treatment of ABL did not have better development regarding academic motivation than those did not receive it.

4.2.2 Effects of meaningful learning

With regard to RQ2 (regarding the effects of web-mediated ML on students' learning), the results given in Table 5 reveal no significant differences in students' skills in using PowerPoint and Word, learning engagement, and academic motivation between ML group (C1 + C3) and non-ML group (C2 + C4). The researchers thus made further analysis of the effects of web-mediated ML on improving learning engagement and academic motivation from the first week till the end of the semester.

According to the data in Tables 6 and 7, the ML group showed a significant increase in their learning engagement at the end of the semester (mean = 3.4725) in contrast to their pretest (mean = 3.3864) ($p < 0.05$). Meanwhile, the non-ML group showed no significant difference in their learning engagement between its pretest (mean = 3.3582) and posttest (mean = 3.4459) ($p = 0.067$). Thus, in this longitudinal analysis, it is found that the treatment of ML could be effective in developing students' learning engagement.

As for the effects of ML on students' academic motivation, it is also found that the ML group showed a significant increase in their academic motivation at the end of the semester (mean = 4.8057), in contrast to their pretest (mean = 4.5775) ($p < 0.001$). Moreover, the non-ML group also showed a significant increase in their academic motivation with posttest (mean = 4.6895) in contrast to their pretest (mean = 4.4328) ($p < 0.01$). This means the expected effects of ML on developing learners' academic motivation are not verified in this study.

5 Discussion and implications

Networked societies and digital media currently figure prominently in our daily lives [125]. While the implementation of e-learning and adoption of educational technologies has reached advanced stages in developed nations, it is still at its beginning in many developing countries [1]. Moreover, it is advised that teachers should consider innovative teaching approaches and redesign a course, instead of just converting existing content by providing it through an online, flipped, or blended course platform for students [15]. In this regard, the researchers in the present study adopted practical teaching methods and strategies of ABL and ML in an online computing course to develop students' skills in using PowerPoint and Word and also enhance their learning engagement and academic motivation for this course. The researchers hope this study can provide a reference and insight for teachers and decision makers in online education and computing education.

With the development of educational technologies and an increase in the number of online classes being taught at the university level, online educators are exploring ways to create collaboration in the web-mediated learning environment [19]. However, research on the effects of the use of the Internet and technology on students' learning is inconclusive as there is a longstanding debate about the impact of Internet use and gameplay on students' learning outcomes [131]. Thus, the researchers in this study redesigned a computing course with the treatments of web-mediated ABL and ML and examined the outcome on enhancing students' skills in using PowerPoint and Word, learning engagement, and academic motivation.

As many educators have argued that students face difficulty when learning through collaboration in a teacher-led learning environment, several strategies of student-centered approach have been proposed [13]. In this regard, this study may contribute to the field of e-learning and online education in the following three ways. First, the researchers designed the involved computing course according to its practical orientations and students' specific needs in this modern society. Second, this study and the design of web-mediated ABL and ML may provide references for online educators to enhance their students' learning outcomes in an online or blended course by integrating effective and practical teaching methods and technologies. Finally, this research may be one of the early attempts to adopt ABL and ML simultaneously in an online course to develop students' computing skills, and also empirically measure students' learning effects, learning engagement, and academic motivation. These contributions may provide inspiration for schools and teachers who expect to provide effective teaching methods and online courses to their students.

5.1 Effects of activity-based learning

The teaching approach in higher education has been shifting from teacher-centered to student-centered for quite some years [16]. According to previous research [36, 107], ABL could be more effective than traditional learning methods. Therefore, the authors in this study integrated ABL in an online computing course to boost students' learning. However, the data in Tables 2, 3, and 4 indicate that no significant differences in students' skills in using PowerPoint and Word, learning engagement, or academic motivation resulted between ABL and non-ABL groups. In addition, it is also

Table 2 Comparison of students' computing skills, learning engagement, and academic motivation between ABL and non-ABL groups

Dependent variable	Group										
	ABL				Non-ABL						
	n	*M*	SD	SE	*n*	*M*	SD	SE	*t*	*df*	Sig. (two-tailed)
Computing skills	86	92.62	15.416	1.662	77	93.36	14.307	1.630	− 0.320	161	0.750
Learning engagement	86	3.4786	0.43436	0.04684	77	3.4409	0.43485	0.04956	0.553	161	0.581
Academic motivation	86	4.7881	0.70195	0.07569	77	4.7168	0.64102	0.07305	0.674	161	0.501

Table 3 Paired samples statistics: the effects of ABL on learning engagement and academic motivation

Dependent variable	Group	Pre–post	*M*	*n*	SD	SE
Learning engagement	ABL (C1 + C2)	Pretest	3.3917	86	0.42449	0.04577
		Posttest	3.4786	86	0.43436	0.04684
	Non-ABL (C3 + C4)	Pretest	3.3541	77	0.38898	0.04433
		Posttest	3.4409	77	0.43485	0.04956
Academic motivation	ABL (C1 + C2)	Pretest	4.5570	86	0.60000	0.06470
		Posttest	4.7881	86	0.70195	0.07569
	Non-ABL (C3 + C4)	Pretest	4.4650	77	0.57102	0.06507
		Posttest	4.7168	77	0.64102	0.07305

Table 4 Pair-wise comparison of students' learning engagement and academic motivation between ABL group and non-ABL group

Dependent variable	Group	Posttest–pretest mean	SD	SE	*t*-value	*df*	*p*
Learning engagement	ABL	0.08690	0.36658	0.03953	2.198	85	0.031*
	non-ABL	0.08681	0.37429	0.04265	2.035	76	0.045*
Academic motivation	ABL	0.23106	0.58260	0.06282	3.678	85	0.000*
	non-ABL	0.25178	0.59585	0.06790	3.708	76	0.000*

* $p < 0.05$

Table 5 Comparison of students' computing skills, learning engagement, and academic motivation between ML and non-ML groups

Dependent variable	Group										
	ML				Non-ML						
	n	*M*	SD	SE	*n*	*M*	SD	SE	*t*	*df*	Sig. (two-tailed)
Computing skills	91	94.30	13.964	1.464	72	91.29	15.863	1.870	1.285	161	0.201
Learning engagement	91	3.4725	0.43599	0.04570	72	3.4459	0.43329	0.05106	0.388	161	0.698
Academic motivation	91	4.8057	0.66462	0.06967	72	4.6895	0.68197	0.08037	1.096	161	0.275

Table 6 Paired samples statistics: the effects of ML on learning engagement and academic motivation

Dependent variable	Group	Pre–post	*M*	*n*	SD	SE
Learning engagement	ML	Pretest	3.3864	91	0.40452	0.04240
	(C1 + C3)	Posttest	3.4725	91	0.43599	0.04570
	non-ML	Pretest	3.3582	72	0.41307	0.04868
	(C2 + C4)	Posttest	3.4459	72	0.43329	0.05106
Academic motivation	ML	Pretest	4.5775	91	0.56985	0.05974
	(C1 + C3)	Posttest	4.8057	91	0.66462	0.06967
	non-ML	Pretest	4.4328	72	0.60115	0.07085
	(C2 + C4)	Posttest	4.6895	72	0.68197	0.08037

Table 7 Pair-wise comparison of students' learning engagement and academic motivation between the ML and non-ML groups

Dependent variable	Group	Posttest–pretest mean	SD	SE	*t*-value	*df*	*p*
Learning engagement	ML	0.08618	0.34544	0.03621	2.380	90	0.019*
	non-ML	0.08772	0.39947	0.04708	1.863	71	0.067
Academic motivation	ML	0.22829	0.56454	0.05918	3.858	90	0.000*
	non-ML	0.25672	0.61821	0.07286	3.524	71	0.001*

*$p < 0.05$

found that both the ABL and the non-ABL groups showed significant development in their learning engagement and academic motivation at the end of the semester. In other words, the treatment of web-mediated ABL did not contribute to improved development of learners' skills in using PowerPoint and Word, learning engagement, and academic motivation, compared with those who did not receive it.

Although the anticipated effects of ABL on developing students' skills in using PowerPoint and Word, engagement, and academic motivation were not shown in this study, the nonsignificant differences and results may be due to many students at private universities in Taiwan being unwilling or unable to take responsibility for their learning, and tending to follow their teachers' arrangements for their learning [118]. It is also noted that it is very difficult to change students' learning habits with a one-semester intervention. Teachers may have to spend more time to change students' attitudes toward learning, and request assistance from the university or ask for cooperation from other teachers within the department to regulate students' learning behavior [106, 130]. Students could still have benefitted from the treatment of ABL and educational technologies, even though it did not improve students' learning more than non-treatment in this study.

5.2 Effects of meaningful learning

As given in Tables 6 and 7, a significant increase was observed in students' learning engagement in the ML group by the end of the course ($p < 0.05$), while the development of students' learning engagement in the non-ML group is not significant. This finding is similar to Endres and Renkl's [23] and Poikela et al.'s [97] studies, which indicates that ML methods are effective in students' learning process. That is, the adoption of online ML may be beneficial for students' development of their learning engagement. Thus, it is suggested that online teachers could integrate ML in their courses to help their students engage well.

Although the treatment of online ML was found to enhance students' learning engagement, the data in Tables 5, 6, and 7 show both ML group and non-ML group had significant development in their academic motivation at the end of the semester. That is, the application of ML in an online course could develop students' learning engagement; however, the inherent motivation is not effectively enhanced in this study. This nonsignificant difference in students' academic motivation with or without ML may result from the limited duration of the experiment (one semester). It is revealed by Lai and Hwang [70] that a short period may be insufficient to reveal a causal relationship. Furthermore, Tsai et al. [121] also describe that the anticipated effects of innovative pedagogy in an online setting over only one semester may be limited when students' other courses still use traditional "spoon-feeding" approaches to teaching. It is suggested that other educators could adopt ML and measure its effects on improving different variables of students' online learning in future studies.

5.3 Potential limitations and problems of this study

The researchers in this study integrated ABL and ML with educational technologies and investigated their influences on improving learners' skills in using PowerPoint and Word, learning engagement, and academic motivation. Before the experiment began, researchers first checked whether students learned Word and PowerPoint prior to this course, and also conducted a pretest to evaluate students' and measure their initial learning engagement and academic motivation. However, there may still exist potential threats to the quasi-experimental design. In addition, the possible impact of learners' readiness for online learning may affect their learning effects [117]. These factors of quasi-experimental design and individual differences may potentially influence validity in this study. Future researchers and teachers who may apply ABL and ML with educational technologies in their online or blended courses should be aware of these factors that may impact the effects of web-mediated ABL and ML claimed in this study.

6 Conclusion

There have been growing challenges for educators in finding new classroom strategies and coping with the millennial generation in the classroom [7, 114]. Recent research emphasizes the need for the concepts of meaningful learning embedded in course design [35, 69]. This research shows the adoption of the activity-based pedagogic approach, as well as meaningful learning, based upon the authors' experiences of working within higher education.

In the results obtained from this research to answer RQ1, it is found that the treatment of web-mediated ABL did not contribute to sharpen learners' computing skills, nor elevate learning engagement or academic motivation when compared to non-ABL treatment. As for RQ2, the analysis in this study indicates that students who received web-mediated ML showed significant improvement in their learning engagement. Notwithstanding its limitations, this study does suggest that ABL and ML remain partly effective. In that case, with further adjustments, the study could still be useful to teachers who want to employ ABL or ML in course design. These results regarding the implementation of web-mediated ABL and ML in an online environment can provide innovative references and insights for online teachers who attempt to adopt new teaching approaches to help their students develop practical computing skills, and engage well in web-mediated learning environments. This may be particularly helpful for those teaching the solving of ill-structured problems or those students who have received traditional lecture or didactic pedagogy for years, such as in Taiwan, Korea, Singapore, and Japan.

Furthermore, it is also suggested that future educators and researchers could adopt other innovative teaching methods integrated with educational technologies to facilitate students' learning. In addition to students' grades, other psychological factors, such as students' involvement, motivation, self-directed learning readiness, and experience of online learning, are also critical qualities when measuring students' online learning performance. Besides gender and age influence, recent research also mentions that culture could be an important factor regarding technology acceptance within educational institutions [55, 102, 103, 115]. Thus, the authors suggest that future studies could take culture as one of the important variables when measuring students' online learning effects under innovative teaching methods.

Funding Funding was provided by Ministry of Science and Technology, Taiwan (Grant No. MOST 106-2511-S-130-007).

Appendix

Learning tasks in the involved course in this study

Microsoft Word	Microsoft PowerPoint
1. Quiet World Spa Villa	1. Self-introduction of Wang, Xiao-Ming
2. Residential Lease Agreement	2. Travel Photo Album
3. Summer International Airfare	3. Tea
4. Four Books and Five Classics	4. A small performance
5. Summary of key points and assessments	5. A report of a book
6. University Badminton Championship	6. Xiao-Ming's travel savings plan
7. Transcript	7. Trade Export Data
8. Major League Baseball Scores	8. Famous Quotes
9. Semiannual Calendars	9. Introduction on cloud computing
10. Studio Apartment for Rent	10. Introduction on Butterflies of Taiwan
11. Formosan Aboriginal Culture Village Sakura Festival	
12. Superstar cellist YO–YO MA	
13. Taipei 3C Fair	
14. Sun Moon Lake Marathon	
15. Grab-bag Specials	

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