Article

active learning in higher education

Active Learning in Higher Education
1–13

DOI: 10.1177/1469787415589532
alh.sagepub.com
SAGE

The effects of ePortfolio-based learning model on student self-regulated learning

Lap Trung Nguyen
Hoa Sen University, Vietnam

Mitsuru Ikeda
Japan Advanced Institute of Science and Technology, Japan

Abstract

Self-regulated learners are aware of their knowledge and skills and proactive in learning. They view learning as a controllable process and accept more responsibility for the results of this process. The research described in this article proposes, implements, and evaluates an ePortfolio-based self-regulated learning model. An ePortfolio system was developed based on self-regulated learning theories. This ePortfolio system was used in designing a learning model for fostering self-regulated learning in higher education. Two surveys were conducted with the Motivated Strategies for Learning Questionnaire at the beginning and at the end of the courses. The differences in Motivated Strategies for Learning Questionnaire scales between pre-test and post-test, or control group and experimental group were evaluated. The trace data of learning activity were also analyzed to evaluate the effects of the learning model on students' self-regulated learning. The results show that students implemented self-regulated learning processes, and their intrinsic goal orientation, metacognitive self-regulation, effort regulation, elaboration, rehearsal, and critical thinking improved after applying ePortfolio-based learning model in the courses. In conclusion, the ePortfolio system and the proposed learning model had positive effects on students' self-regulated learning skills.

Keywords

competency measuring, ePortfolio-based learning, self-regulated learning

Self-regulated learning

From the process perspective, self-regulation is a self-directive process in which students convert their mental abilities to academic skills, and learning is a proactive process in which students actively participate with major responsibility and motivation (Zimmerman, 2002). The structure and function of self-regulatory processes are expressed in terms of three cyclical phases: forethought, performance, and self-reflection. In terms of learners' characteristics, self-regulated learners are aware

Corresponding author:
Lap Trung Nguyen, Hoa Sen University, 8 Nguyen Van Trang Street, District 1, Ho Chi Minh City 700000, Vietnam.
Email: lap.nguyentrung@hoasen.edu.vn

when they know a fact or possess a skill, and they use metacognitive, motivational, and behavioral strategies to achieve their goals (Zimmerman, 1990). Thus, self-regulated learners should have some skills, such as setting goals, planning strategies, monitoring performance, changing the context, managing time, evaluating methods, attributing causation results, and adapting future methods (Zimmerman, 2002). An integrated model was constructed which consists of four phases of self-regulated learning—task definition and planning, monitoring, control, and reaction and reflection—and four areas for regulation—cognition, motivation, behavior, and context (Pintrich, 2004).

Research shows that self-regulated learning has positive effects on learners' success in and beyond school (Winne, 2005a; Zimmerman, 2002). Indeed, self-regulated learning skills are widely recognized as key factors in academic success at university (Warburton and Volet, 2012). Self-regulated learners tend to have high motivation and confidence for learning and to use productive problem-solving skills. Those characteristics lead to relevant behavior and also a high level of achievement (Perry and Winne, 2013). In addition, the research revealed students' awareness of how their approach to study affected the quality of their learning (Warburton and Volet, 2012). The use of metacognitive learning strategies and motivation for learning increases in learning environments with self-regulated learning opportunities (Vrieling et al., 2012). These points explain why self-regulated learning affects students' achievements. Self-regulated learning may be taught or fostered (Winne, 2005a; Zimmerman, 2002). Self-regulated learning emerges from two essential sources: social and self-directed experiences (Zimmerman, 1998). The "self" in self-regulated learning implies that the learner regulates learning; however, self-regulation does not mean solo (Perry and Winne, 2013). Learners' development of self-regulated learning depends on support from others, for example, teachers or peers.

In order to teach and promote self-regulated learning, a number of instructional models were developed, as summarized in Zimmerman (1998). These models share not only a core set of social and self-directed experiences, such as modeling, strategy training, verbal tuition, and academic practice, but also the view of self-regulated learning processes that involve forethought, performance, and self-reflection phases. In summary, self-regulated learning research explains how self-regulated learners are successful in and beyond school. Self-regulated learning can be taught and fostered. It is necessary to support instructors to provide self-regulated learning practices and scaffold learners in order to develop their self-regulated learning skills.

Fostering self-regulated learning

Learning depends on an interaction among external environmental factors and the students' knowledge and skills, as well as interactions among students and between students and the instructor. Therefore, different learning environments may support different outcomes related to self-regulated learning (Stefanou et al., 2013). Therefore, students need significant support to regulate their learning and make self-regulated learning productive (Winne, 2005a, 2010). Self-regulated learning skills may be fostered by technology-enhanced learning environments (Bartolomé and Steffens, 2011; Devolder et al., 2012; Steffens, 2001). Scaffolding is not just interactions between humans; such interactions have been extended to include the use of technological tools, resources, and environments. More specifically, computer-based learning environments can be used as self-regulatory tools to enhance learning (Zimmerman and Tsikalas, 2005). The self-regulatory processes in three phases of self-regulated learning models (forethought, performance, and self-reflection) were examined if and how they can be supported by computer-based learning environments (Zimmerman and Tsikalas, 2005). For example, a process visualization tool can enhance task analysis, computer-based learning environment feedback can support learners in focusing and monitoring, or self-evaluation tools assist learners in evaluating the quality of their work.

Online measures of self-regulated learning are described with computer traces (Zimmerman, 2008) with the support of the computers; these online measures show how learners become masters in learning. From this perspective, computer-based environments show potential for fostering to the uses of self-regulated learning. For more examples of computer-supported self-regulated learning, a system to support the recording of activity data and then enhance self-regulated learning measuring was introduced (Perry and Winne, 2006). In addition, there were some tools to support the collaborative and socio-cognitive aspect of self-regulated learning (Hadwin et al., 2010; Holocher-Ertl et al., 2011).

In a publication about the key issues in modeling and applying research on self-regulated learning, Winne (2005b) argued that we have lacked tools for gathering data about the events that constitute self-regulation. These data and tools are very important for evaluating and modeling self-regulated learning. In addition, it is argued that a key to developing self-regulated learners is linking the processes through the forethought, performance, and self-reflect phases (Zimmerman and Tsikalas, 2005). Thus, computer-based learning environments that support self-regulatory processes in all three phases are more likely to support self-regulated learning better. However, the literature does not report any model or tool that can fully handle these issues.

A relevant environment for fostering self-regulated learning is ePortfolio. “An ePortfolio is a purposeful aggregation of digital items—ideas, evidence, reflections, feedback, etc., which presents a selected audience with evidence of a person’s learning and/or ability” (JISC, 2008). In addition, ePortfolios are argued to be technology-enhanced learning environments that have the potential to foster self-regulated learning (Bartolomé and Steffens, 2011), and educators believe that ePortfolios allow learners to think critically and become active, independent, and self-regulated learners (Abrami et al., 2008).

ePortfolio for self-regulated learning

A portfolio is defined as a purposeful collection of student work that demonstrates the students’ efforts, progress, improvement, and achievements (Barrett, 1998; Paulson et al., 1991). From the definitions of portfolios, an ePortfolio is defined by JISC (2008) as the product, created by the learner, a collection of digital artifacts articulating experiences, achievements, and learning. The literature shows that ePortfolios, competency, and self-regulated learning are related to each other. For example, competency measuring affects self-regulated learning (Voorhees, 2001; Zimmerman, 2002, 2008), ePortfolios improve competency measuring (Gadbury-Amyot et al., 2003; Rao et al., 2012), and ePortfolios provide a relevant environment for practicing self-regulated learning skills (Abrami et al., 2008; Hadwin et al., 2010; Perry and Winne, 2013; Ryan and Ryan, 2012). Thus, ePortfolios improve competency measuring, demonstrating that both ePortfolios and competency measuring can foster self-regulated learning. This assumption leads to the idea of fostering self-regulated learning by embedding the above components into a unified environment. Next, we discuss more details of the relationships among ePortfolios, competency measuring, and self-regulated learning.

Competency measuring affects self-regulated learning

In general, competencies are knowledge and skills that are needed for a person to perform an activity well. In learning, competencies are learning outcomes and prerequisite knowledge and skills for learning (Voorhees, 2001). In order to learn well, learners should have acquired the applicable knowledge and skills. Thus, competency evaluation plays an important role in learning, especially in self-regulated learning. Competency evaluation is more critical because learners are required to evaluate their competencies, achieved learning outcomes, and performance in order to regulate their learning in the future (Zimmerman, 2002). From the integrated model of self-regulated learning (Pintrich, 2004), we can see the role of competency evaluation in self-regulated learning phases. In the forethought phase, competency evaluation skill allows learners to set goals, judge efficacy, or plan time and effort more effectively based on the current status of their competencies. In the monitoring and control phases, this skill helps learners realize which competencies they have achieved or the levels of competencies that are outcomes of current learning activities. In other words, evaluating competency enhances awareness of cognition, motivation, behavior, and context. It also supports learners in selecting and changing learning strategies. Especially, in the reflection phase, learners have to evaluate their cognition and tasks, and these activities relate to competency evaluation directly. It is claimed that students need significant support to regulate their learning and make self-regulated learning productive (Winne, 2005a, 2010). In order to support learners well, external agents should have the ability to evaluate learners' competencies or performances. From this perspective, competency evaluation also affects learners' self-regulated learning by enhancing the ability of supporters.

ePortfolios improve competency measuring

An ePortfolio is a collection of digital artifacts which show the experiences or abilities of the author (JISC, 2008). In education, ePortfolios are used to support teaching and learning. They not only store achievements but also show the processes of reaching those achievements (Rao et al., 2012). ePortfolios are used to document competencies and examine how students reflected on their competency development process (Zawacki-Richter and Hanft, 2011). ePortfolios contain evidence of competencies, which are achieved during learning. Evidence includes artifacts that were created as output of learning activities. Evidence also involves processes that show how learners achieved the competencies. An ePortfolio is a tool which can store, visualize evidence, and provide features for evaluation operations. In addition, the ePortfolio contains models that represent the principles of competency models and explain how to evaluate competency in a reasonable way. From these perspectives, ePortfolios help learners and external evaluators to better understand competency and improve their ability to evaluate it.

ePortfolios foster self-regulated learning

ePortfolio systems are relevant environments for reflection and collaboration between students and peers, or students and teachers (Ryan and Ryan, 2012). These advantages allow learners to use ePortfolio systems as a platform for practicing self-regulated learning processes through the self-regulated learning phases. This is very important in fostering self-regulated learning (Hadwin et al., 2010; Perry and Winne, 2013). With the ability to trace learning processes, ePortfolio systems enable learners to monitor their learning. ePortfolio systems are platforms for reflection because learners can review, evaluate their performances by observing what the ePortfolio systems captured, and then make changes in learning strategies to reach their goals. In general, this method of learning aligns with the theory of self-regulated learning. Reflection and evaluation play important roles in self-regulated learning because self-regulation is based on self-reflection and self-evaluation (Zimmerman, 2002). Other features of ePortfolios are representation and cooperation (JISC, 2008)—learners can show their results to others and cooperate with others in ePortfolio systems. These advantages can promote the intrinsic motivation of learners, which is an important factor in self-regulated learning (Pintrich, 2004; Zimmerman, 2002).

In summary, competency is a component of an ePortfolio, and ePortfolio systems are potential platforms for competency assessment. Evaluating competency is a central activity in self-regulated learning as it affects self-regulated learning processes and results directly. Reflection and motivation are two of the factors that link ePortfolios and self-regulated learning together. Considering these points of view, the use of ePortfolio systems is assumed to foster competency evaluation, reflection, and then self-regulated learning.

There are some issues concerning ePortfolios for self-regulated learning. The research in this field was based on the traditional structure of ePortfolios, which were unable to implement self-regulated learning processes. Currently, no ePortfolio models for self-regulated learning are available. Past research has focused on the presentation layer of ePortfolios to explain their abilities. Thus, research that takes self-regulated learning models into consideration when developing ePortfolio systems is unavailable. Consequently, there is an absence of explicit ePortfolio models for self-regulated learning. The literature also does not explore the relations among ePortfolios, competency, and self-regulated learning explicitly. Therefore, examination of various combinations of these components is necessary in order to improve our understanding of the relations. In addition, there is a lack of reports about the impacts of such ePortfolio models on self-regulated learning. More knowledge about whether or how ePortfolio systems affect student self-regulated learning is needed.

The goals of this study are to present a systematic analysis of the relationships among ePortfolios, competency, and self-regulated learning; propose an ePortfolio-based learning model; and examine the effects of self-regulated learning-based ePortfolio systems on students' self-regulated learning. It is argued that the integration of ePortfolios, competency models, and self-regulated learning into a unified platform can promote the synergic relations among them and foster self-regulated learning. In addition, it is argued that ePortfolio systems based on the proposed integrated model positively affect the regulation areas and processes of the self-regulated learning model described in Pintrich (2004). The research questions that guide this study are as follows: (1) Does the proposed model foster self-regulated learning? (2) Does the model affect students' motivation and learning strategies? and (3) If so, which areas are affected and how does the learning model impact student learning?

Research method

ePortfolio-based learning model

Based on the above analyses and self-regulated learning models, an ePortfolio system was developed. The focus was on improving ePortfolios' capacity for measuring competencies, capturing and sharing self-regulated learning principles, and practicing self-regulated learning processes. The system helps instructors to design programs, create program plans, observe learning activities, evaluate learning outcomes, give feedback, and hold discussions with students. A program in the ePortfolio system is an academic program (e.g. Bachelor of Computer Science) or a course in a program (e.g. Data Structures and Algorithms (DSA)). Students can use the system to create learning plans, manage artifacts, monitor learning processes, evaluate task progresses and learning outcomes, and reflect on feedback and results. The system is a platform for interactions between students and instructor and among students.

The ePortfolio system is used to design learning. ePortfolio-based learning is integrated into courses and is used as a supplement that supports formal class activities in order to foster students' self-regulated learning skills. The uses of the ePortfolio system are as follows. Instructors use the ePortfolio system to design programs (courses). Program activities and competencies are added in hierarchical structures. Next, for each activity, its prerequisite competencies and outcome competencies are specified. Then, instructors create a program plan that consists of stages, activities in these stages, and resources for these activities. These components of a program are created based on a course outline and can be shared or reused among instructors.

Students who take a course will join a corresponding program in the ePortfolio system as well. Students are asked to create their personal plans based on the program plan, their goal, and their personal conditions. Personal plans and program plans have the same structures; however, program plans contain activity types of subjects, while personal plans involve particular activities of students, which are instances of the activity types in the program plans. From their personal plans, students can observe the structure, time period, and progress of activities. Students can select an activity in the plans to refer to other related elements such as resources, output artifacts, prerequisite competencies, and goal competencies. In plan forms, students also can participate in program discussion with all students and instructors of the course.

An evaluation form for an activity is used by students and instructors. This form appears after evaluators select a student and an activity in the plan. The first part of this form contains information about the time period, time passed, and progress of the activity. The second part lists all artifacts that are the outputs of the current activity. The goal competencies of the activity are shown in the next part, in which evaluators can check evidence and update the levels of competencies. The last part contains the discussions that are related to the activity type of the selected activity.

Data collection and analysis

The first experiments were conducted at Hoa Sen University, Vietnam. The ePortfolio system was used in two courses: DSA and Software Development Processes and Tools (SDPT). The DSA class had 48 first-year students, who were split into two groups (for computer lab room section); randomly one group was selected, and in the selected group, voluntary students were called to use the ePortfolio system for learning. In the SDPT class, all 18 fourth-year students were recommended to use the ePortfolio system for this course. The students used the ePortfolio system for learning for 8 weeks.

Self-report

To measure self-regulated learning, a self-reporting method with the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991) was used. MSLQ allows us to measure different motivational components and the use of learning strategies in a given course. The underlying assumption in this method is that self-regulation is an aptitude that students possess. The MSLQ consists of six motivational and nine learning strategies subscales. The six motivation subscales measure intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy, and test anxiety. The nine learning strategy subscales measure rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, effort regulation, peer learning, and help seeking. The MSLQ consists of 81 questions, which the students rated using a Likert scale from 1 "not at all true of me" to 7 "very true of me."

MSLQ surveys were conducted in DSA and SDPT classes in the first and the last weeks of the semester. All students were told before the survey that their participation was voluntary and not related in any way to their grades in the course. With self-report scores, to examine how the ePortfolio system affected students' learning, the mean differences between groups were evaluated using two-tailed t-test with p-values <0.05 considered significant (Cheang, 2009).

For the first study in SDPT class, the mean scores of each scale in MSLQ of all 18 students before and after using the ePortfolio system were compared using paired t-test. For the second study in DSA class, three kinds of comparisons were conducted to evaluate the effects of the ePortfolio system: the differences between the control group and the experimental group at the end of semester using post-test results, the differences between pre-test and post-test in both groups, and the differences between the control and the experimental group's change.

A controlled experiment is an experiment setup designed to test hypotheses. It has one or more conditions and measures (Kirk, 2013). In this context, the hypothesis is that the motivated strategies for learning scores will differ between students who use the ePortfolio system for learning and students who do not use ePortfolios. In other words, the use of ePortfolios affects MSLQ scores. In addition, the use of the ePortfolio system is the condition (or independent variable), and MSLQ scores are measures (dependent variables). The study compares the MSLQ scores of students under two conditions: learning with and without ePortfolios. The study does not measure and compare learning or the effects of ePortfolios directly but measures only MSLQ scores instead. Therefore, it is reasonable to conclude that the results of the control and experimental groups can be validly compared.

Trace data

A trace method was used for measuring and exploring students' self-regulated learning skills using the ePortfolio system. In previous studies (Hadwin et al., 2007; Perry and Winne, 2006; Zimmerman, 2008), the authors argued the benefits of using trace methodology to examine the dynamic perspective of self-regulated learning. The most common type of data collected are computer logs, which can record students' learning activity in a computer-based learning environment.

Currently, the ePortfolio system can log nine primary types of activities:

- Create plan: When students join a program and create a personal plan;
- Update Plan: When students add and change stages or types of activity in a plan;
- Create artifact: When students add artifacts;
- Update artifact: When students change information of existing artifacts;
- Evaluate activity: When students set and update progress;
- Evaluate competency: When students set and update level of competency;
- Set competency evidence: When students set output of activity when create/update artifacts;
- Discuss learning: When students post and respond to discussions;
- Review feedback: When students read discussions, view evaluations, and view plans.

Logged data are saved as XML files. The log file was analyzed to examine the frequency and sequence of learning activities. Time-based analysis was used to evaluate the changes in learning over time. Log data can show how students interact via the ePortfolio system, for example, the sequence in which activities are usually carried out. By employing this analysis, students' self-regulated learning was understood, and the patterns of activity with the ePortfolio system were identified. In addition, analysis of these patterns allowed inferences to be made as to how students' engagement in self-regulated learning could be improved, and their learning fostered.

Results

Self-report data

In the SDPT class, 18 responses were collected for both pre- and post-tests. In the DSA class, 27 responses for the pre-test and 39 responses for the post-test were received. After the post-test, based on the logged data, a control group with 25 students and an experimental group with 14 students were determined. The students who did not use the ePortfolio system comprised the control group. In the control group, 13 students responded to both pre- and post-tests, while experimental group had 10 students who responded to both tests. All "reversed" items in MSLQ were reversed before scores were computed. In the study with the SDPT course, all 18 students used the ePortfolio system. In order to evaluate the effects of the ePortfolio system on motivation and learning strategy subscales, a paired two-tailed t-test was used to examine the differences between pre-test and post-test.

The effects of the ePortfolio system on students' motivation and use of learning strategies are now summarized. Data described in this and the remaining parts of the results section can be obtained from the authors. Positive effects were reported in 13 scales. The data show that the use of the ePortfolio system might contribute to significant improvements in some scales, such as metacognitive self-regulation ($p = 0.001$), critical thinking ($p = 0.002$), elaboration ($p = 0.004$), and rehearsal ($p = 0.028$). These scales relate directly to self-regulated learning (Pintrich, 2004); hence, it is reasonable to argue that the system implemented had positive effects on students' self-regulated learning skills. Although not statistically significant, improvement was seen in task value ($p = 0.057$) and intrinsic goal orientation ($p = 0.069$). Two scales show negative effects, but neither are significant (help seeking, $p = 0.452$; time/study environment management, $p = 0.872$). Overall, MSLQ scores indicate that the system affected students' learning in a positive manner. Therefore, the ePortfolio system promoted students' motivation and learning strategies.

In the study with the DSA course, first, the means of scales of post-tests in two groups were compared using unpaired two-tailed t-test. The results show that the experimental group is dominant in all scales (control mean < experimental mean, except test anxiety scale, but it means that there is less worry in the experimental group). The experimental group's scores are significantly higher on some scales that relate to self-regulated learning, such as intrinsic goal orientation ($p < 0.001$), effort regulation ($p = 0.002$), self-efficacy for learning and performance ($p = 0.012$), elaboration ($p = 0.023$), metacognitive self-regulation ($p = 0.032$), and task value ($p = 0.036$). In addition, the differences in control of learning beliefs ($p = 0.066$), organization ($p = 0.07$), and rehearsal ($p = 0.095$) were also considered. This comparison supports the results of the previous study in the SDPT class.

For the second kind of evaluation, the degrees of change of two groups were compared using an unpaired two-tailed t-test. Although not significant ($t = -1.32$; $p = 0.198$), the results show that the experimental group is dominant on 11 scales. In addition, the experimental group has 5 scales in negative change (post-score < pre-score), while the control group has 10 negative scales. Especially, some scales had opposite changes: positive change in the experimental group, but a negative change in the control group, such as metacognitive self-regulation, intrinsic goal orientation, task value, and self-efficacy for learning and performance. The three biggest changes were elaboration (experimental: 0.517), effort regulation (experimental: 0.65), and rehearsal (control: 0.75). This comparison shows that the ePortfolio system improved the positive changes, while it limited the negative changes in student learning.

The mean differences between pre-test and post-test scores for both groups were examined. A paired two-tailed t-test for each group was conducted. The data show that the changes are not significant in either group. For the control group, only the rehearsal scale demonstrated a significant change ($p = 0.041$), while there was no significant change in the experimental group. However, the change in the effort regulation scale of the experimental group ($p = 0.095$) should be noted. This comparison is not consistent with the test in the SDPT class. This result suggests that the effects of this learning model were course-dependent and subject to influence by the course's contents or the instructors' intentions.

Trace data

Trace data were stored in XML files, each element containing information about a performed activity, such as participants, time, which activity, and which course. A log analyzer was developed to generate frequency counts and transition statistics. From this information, transition matrices and transition graphs were created. In this report, only the trace data of the SDPT course were examined because all students in this class used the ePortfolio system.

Frequency of learning activity. Overall, the data indicate considerable variance in the number of activities performed by each student (mean = 100.4, standard deviation (SD) = 68.3). Although all types of activities were performed using the system, there were significant differences in the percentage of types. "Review feedback" (46%) and "evaluate activity" (24.4%) are the most frequent activities. Data also show that students rarely discuss learning with other students via the system. Discussion took 2.9%, and each student discusses 3.4 times on average. The data suggest that further investigation of how the system encourages students to engage in self-regulated learning activities is needed in order to identify what should be improved in order to support students better.

Transition of learning activity. The overall sequences of activities were examined to highlight the patterns of learning activity. Self-regulated learning strategies contain multiple activities. Thus, to understand students' self-regulated learning, the transitions among specific activities should be considered. Transition matrices and transition graphs were used to represent the patterns of learning activity.

Results show that students performed 50/81 of possible transition types. "Create plan" is the first activity; after that, students can update plan, create artifact, or review feedback. "Review feedback" and "evaluate activity" are not only the most frequent activities but also the most central activities. "Review feedback" connects to the other seven activities and can be the end points of transitions that begin with the other activities. "Evaluate activity" links to the other six activities in both directions. This finding indicates that by using the system, "review feedback" and "evaluate activity" become the central tactics of learning strategies. Students usually review feedback (e.g. observe discussions, evaluations, progress, and personal plan) and evaluate task progress before and after doing other activities. This pattern of learning aligns with reflection-based learning and supports self-regulated learning.

A transition graph is formed by nodes and directional lines; each node is represented by a type of activity with its respective percentage. In general, the more the active learners, the more the nodes and transitions in the transition graph. A graph can demonstrate the general trend of the classes' use of learning strategies in a particular period. Thus, by comparing the graphs, the changes in learning trends over time can be examined. The transition graph shows that the students learned quite actively because all nodes were connected to others with 50 patterns of transition. In addition, the activities and transitions in the graph are the elements that create or relate to the self-regulated learning processes (Pintrich, 2004; Zimmerman, 1998, 2002). Thus, students were engaged in self-regulated learning with a variety of tactics.

Time-based analysis. The data were collected in three stages to check the change of activity distributions and transitions over time: the intervals were the first 3 weeks, the next 2 weeks, and the last 3 weeks. However, the second stage included a long holiday, and thus, this report focuses on the first and the last stages. A chart represents the changes of activities. The chart shows that "evaluate activity" percentage increased from 10.3% (stage 1) to 33.4% (stage 3), while "review feedback" decreased from 64.8% (stage 1) to 33.7% (stage 3). Another significant change came from "evaluate competency," which increased from 3.3% (stage 1) to 11.8% (stage 3). Those changes indicate that students' awareness of performance and achievement was improved. They evaluated themselves more often and interacted with the system more actively beyond observation.

In addition, to examine the changes in transition patterns, two transition matrices of the first and third stages were created. Overall, numbers of transition types over possible types are quite similar (40/81 in stage 1 and 39/81 in stage 3). However, there were differences in patterns of transition between two stages. All the students created their personal plans before stage 3, and the plans seemed to be stable in stage 3. In stage 3, the students usually set evidence for competencies after creating or updating an artifact (98.6% and 34.5% compared to 25% and 3.5% in stage 1). In addition, the students updated their artifacts after other activities less often than in stage 1. These findings explained that the students understood more about the use of artifacts and created high-quality artifacts in stage 3. The percentages of transitions that finished at "review feedback" decreased, whereas the number that finished at "evaluate activity" increased commensurately. The percentage of transition from "review feedback" to itself decreased (82.7% in stage 1 and 61.7% in stage 3), while the transitions from it to "create artifact," "evaluate activity," and "evaluate competency" increased. These findings are consistent with the analysis about the changes in frequency of activities, and they support the arguments for students' improvement over time.

The changes in time-based analysis indicate that the use of the ePortfolio system for self-regulated learning was improved. The students understood more about the system and learning tactics, and they used the system for practicing self-regulated learning skills better over time. For instance, the changes explained that the students not only reviewed the feedback, when the time of use increased, but they also performed other types of activity, for example, self-evaluation.

In summary, the MSLQ scores show that there were significant differences between pre-test and post-test scores, and between control and experimental groups. It is reasonable to infer the positive effects of the ePortfolio-based learning model on student-motivated strategies for learning scales. Consequently, the impact of the ePortfolio system on student self-regulated learning was recognized based on the framework for self-regulated learning assessment employed (Pintrich, 2004). In addition, the trace data show that the students implemented and linked the self-regulated learning processes successfully in the ePortfolio environment. This is a key to developing self-regulated learners (Zimmerman and Tsikalas, 2005). The trace data also indicate that student self-regulated learning skills were improved over time using the ePortfolio-based learning model.

Conclusion

In this research, the relations among ePortfolios, competency, and self-regulated learning were analyzed and synthesized. This knowledge played an important role in developing an ePortfolio model for self-regulated learning. From this model, an ePortfolio system was implemented that can handle the issues of fostering self-regulated learning, for example, self-regulated learning principles representation and sharing, or self-regulated learning processes implementation.

The model and implemented system help us to handle the main issues of fostering self-regulated learning (Winne, 2005b; Zimmerman and Tsikalas, 2005). The results of this study suggest that the combination of self-regulated learning, ePortfolios, and competency promotes self-regulated learning. This combination leads to a unified platform, in which students can practice all self-regulated learning activities. In addition, these activities are logged for the assessment or modeling of self-regulated learning.

The results indicate that the ePortfolio-based learning model positively affected students' self-regulated learning. The use of the self-regulated learning-based ePortfolio system contributed to positive changes in students' motivation and learning strategies. Indeed, the ePortfolio-based learning model affected the MSLQ scales, such as metacognitive self-regulation, critical thinking, elaboration, rehearsal, intrinsic goal orientation, effort regulation, self-efficacy for learning and performance, and task value. These scales are related directly to self-regulated learning and are relevant for self-regulated learning assessment (Pintrich, 2004). More specifically, rehearsal, elaboration, critical thinking, and metacognitive self-regulation were used for cognition area; intrinsic goal orientation, task value, and self-efficacy were used for motivation/affect area; and effort regulation for behavior area of self-regulated learning. The findings explain that the use of ePortfolio systems affects student self-regulated learning by fostering students' motivation and supporting students in performing and developing learning tactics and strategies.

The results also suggest that the effects of the ePortfolio system were course-dependent and subject to influence by the course's contents or the instructors' intentions. Indeed, there was variance in the change of MSLQ scores and the frequency of learning activities of each student and each course. The role of the teacher in this learning model is a critical factor. Instructors need to pay attention to the use of the ePortfolio system to communicate, evaluate, and encourage students over time in order to improve the efficiency of the learning model. However, logged data illustrate that students followed self-regulated learning principles and implemented self-regulated learning skills when using the ePortfolio system in the learning model. In addition, time-based analysis shows that student engagement in self-regulated learning improved over time, indicating that students need time to practice and develop their skills. Data show that students perform a single activity or simple/short sequence of activities (just review feedback) at the beginning but longer processes at the end of the semester (review feedback, evaluate activity, set evidence, and evaluate competency).

These findings contribute knowledge to ePortfolios and the field of self-regulated learning research. More specifically, the results explain whether and how ePortfolio systems affect student learning and what should be considered when we implement ePortfolio-based learning models.

There were some limitations in this research. The MSLQ surveys were conducted at the beginning and end of the semester. Thus, the changes of students' self-regulated learning may have been due to the passage of time rather than the use of the ePortfolio system. There was no Vietnamese version of MSLQ; a bilingual English/Vietnamese version was created and used in this research, which may affect the reliability and validity of the surveys. Another weak point of MSLQ is that although the MSLQ has the potential for assessing self-regulated learning, there is a lack of research that uses MSLQ for this purpose. The number of courses and the small number of respondents were other limitations. The experiments were conducted only with students in software engineering in a unique context, that is, a Vietnamese university. In addition, the learning data of each participant were not analyzed to define the changes in self-regulated learning skills. For future work, there is a need to conduct more experiments with students from different disciplines and contexts. It is necessary to design and implement evaluation with academic programs. Other types of analysis need to be used to explore ways in which the system affects students' learning and what needs to change in order to improve the impact of the system on students' learning, for example, individual level analyses and artifact content-based analyses.

With the need of scaffolding self-regulated learning and the continuous growth of technology in education, ePortfolios may become a potential tool for self-regulated learning. When designing or implementing ePortfolio systems for self-regulated learning, the relationships among ePortfolios, competency measuring models, and self-regulated learning should be taken into account. With these stipulations, the ePortfolio systems become interactive environments, in which instructors and learners can specify and share learning strategies and perform all self-regulated learning processes. The ePortfolio-based learning model in this research may be implemented with a relevant ePortfolio environment in a particular context in order to develop students' motivation and learning strategies. Consequently, student self-regulated learning skills will be improved by practice over time. The courses should be restructured in order to provide opportunities for practicing self-regulated learning processes. Instructors should pay attention to the use of ePortfolios and the differences between students and between particular learning contexts in order to improve the effects of ePortfolios on student learning.

Acknowledgements

We would like to thank ePortfolio group at Hoa Sen University for helping us conduct the experiment. We are also grateful to the anonymous reviewers and the editor for their constructive comments. Furthermore, we would like to thank Professor Bill Holden for his valuable feedback.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

References

Abrami PC, Wade CA, Pillay V, et al. (2008) Encouraging self-regulated learning through electronic portfolios. *Canadian Journal of Learning and Technology* 34(3). Available at: http://cjlt.csj.ualberta.ca/index.php/cjlt/article/viewArticle/507

Barrett HC (1998) Strategic questions: What to consider when planning for electronic portfolios. *Learning and Leading with Technology* 26(2): 6–13.

Bartolomé A and Steffens K (2011) Technologies for self-regulated learning. In: Carneiro R, Lefrere P, Steffens K, et al. (eds) *Self-Regulated Learning in Technology Enhanced Learning Environments*. Rotterdam: Sense Publishers, 21–31.

Cheang KI (2009) Effect of learner-centered teaching on motivation and learning strategies in a third-year pharmacotherapy course. *American Journal of Pharmaceutical Education* 73(3): 1–8.

Devolder A, Braak JV and Tondeur J (2012) Supporting self-regulated learning in computer-based learning environments: Systematic review of effects of scaffolding in the domain of science education. *Journal of Computer Assisted Learning* 28(6): 557–73.

Gadbury-Amyot CC, Kim J, Palm RL, et al. (2003) Validity and reliability of portfolio assessment of competency in a baccalaureate dental hygiene program. *Journal of Dental Education* 67(9): 991–1002.

Hadwin AF, Nesbit JC, Jamieson-Noel D, et al. (2007) Examining trace data to explore self-regulated learning. *Metacognition and Learning* 2(2): 107–24.

Hadwin AF, Oshige M, Gress CL, et al. (2010) Innovative ways for using gStudy to orchestrate and research social aspects of self-regulated learning. *Computers in Human Behavior* 26(5): 794–805.

Holocher-Ertl T, Fabian CM, Siadaty M, et al. (2011) Self-regulated learners and collaboration: How innovative tools can address the motivation to learn at the workplace? In: *6th European conference on technology enhanced learning EC-TEL 2011*, Palermo, 20–23 September, pp. 506–11. Berlin; Heidelberg: Springer.

JISC (2008) *Effective Practice with e-Portfolios: Supporting 21st Century Learning*. Bristol: JISC Innovation Group.

Kirk RE (2013) *Experimental Design Procedures for the Behavioral Sciences*. Thousand Oaks, CA: SAGE.

Paulson FL, Paulson PR and Meyer C (1991) What makes a portfolio a portfolio? *Educational Leadership* 48(5): 60–3.

Perry N and Winne P (2013) Keys to promoting self-regulated learning. *Teacher Newsmagazine* 25(5). Available at: http://bctf.ca/publications/NewsmagArticle.aspx?id=29340

Perry NE and Winne PH (2006) Learning from learning kits: gStudy traces of students' self-regulated engagements with computerized content. *Educational Psychology Review* 18(3): 211–28.

Pintrich PR (2004) A conceptual framework for assessing motivation and self-regulated learning in college students. *Educational Psychology Review* 16(4): 385–407.

Pintrich PR, Smith DA, Garcia T, et al. (1991) *A Manual for the Use of the Motivated Strategies for Learning Questionnaire (MSLQ)*. Ann Arbor, MI: National Center for Research to Improve Postsecondary Teaching and Learning, University of Michigan.

Rao S, Swartz A, Obeid L, et al. (2012) e-Portfolio competency metadata: Pilot study for a call to action. *Journal of Medical Systems* 36(2): 457–62.

Ryan M and Ryan M (2012) A model for embedding reflective learning in ePortfolios in higher education. In: *ePIC 2012: The 10th international ePortfolio and identity conference*, London, 9–11 July, pp. 198–202. Poitiers: ADPIOS.

Stefanou C, Stolk J, Prince M, et al. (2013) Self-regulation and autonomy in problem- and project-based learning environments. *Active Learning in Higher Education* 14(2): 109–22.

Steffens K (2001) Self-regulation and computer based learning. *Anuarion de Psicología* 32(2): 77–94. Voorhees RA (2001) Competency-based learning models: A necessary future. *New Directions for Institutional Research* 2001(110): 5–13.

Vrieling E, Bastiaens T and Stijnen S (2012) Effects of increased self-regulated learning opportunities on student teachers' metacognitive and motivational development. *International Journal of Educational Research* 53(2012): 251–63.

Warburton N and Volet S (2012) Enhancing self-directed learning through a content quiz group learning assignment. *Active Learning in Higher Education* 14(1): 9–22.

Winne PH (2005a) A perspective on state-of-the-art research on self-regulated learning. *Instructional Science* 33(5–6): 559–65.

Winne PH (2005b) Key issues in modeling and applying research on self-regulated learning. *Applied Psychology: An International Review* 54(2): 232–8.

Winne PH (2010) Bootstrapping learner's self-regulated learning. *Psychological Test and Assessment Modeling* 52(4): 472–90.

Zawacki-Richter O and Hanft A (2011) Validation of competencies in e-portfolios: A qualitative analysis. *The International Review of Research in Open and Distance Learning* 12(1): 1–9.

Zimmerman BJ (1990) Self-regulated learning and academic achievement: An overview. *Educational Psychologist* 25(1): 3–17.

Zimmerman BJ (1998) Developing self-fulfilling cycles of academic regulation: An analysis of exemplary instructional models. In: Schunk DH and Zimmerman BJ (eds) *Self-Regulated Learning from Teaching to Self-Reflective Practice*. New York: The Guilford Press, pp. 1–19.

Zimmerman BJ (2002) Becoming a self-regulated learner: An overview. *Theory into Practice* 41(2): 65–70.

Zimmerman BJ (2008) Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal* 45(1): 166–83.

Zimmerman BJ and Tsikalas KE (2005) Can computer-based learning environments (CBLEs) be used as self-regulatory tools to enhance learning? *Educational Psychologist* 40(4): 267–71.

Author biographies

Lap Trung Nguyen's research interests include scaffolding self-regulated learning, technology-enhanced learning environment, and ontology engineering. *Address*: Hoa Sen University, 8 Nguyen Van Trang Street, District 1, Ho Chi Minh City, Vietnam. [email: lap.nguyentrung@hoasen.edu.vn]

Mitsuru Ikeda is a Professor at the School of Knowledge Science, Japan Advanced Institute of Science and Technology (JAIST). He received his PhD degree from Osaka University. His research interests lie in ontology engineering, modeling methods based on ontology engineering, and applying these methods to knowledge management systems and learning support systems. *Address*: Ikeda lab, 8th Floor, KS Building I, School of Knowledge Science, Japan Advanced Institute of Science and Technology, 1-1 Asahidai, Nomi, Ishikawa 923-1211, Japan. [email: ikeda@jaist.ac.jp]