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| Title | 自己調整学習オントロジーに基づくe-Portfolioシステムの設計 |
| Author(s) | Nguyen, Trung Lap |
| Citation | |
| Issue Date | 2014-12 |
| Type | Thesis or Dissertation |
| Text version | ETD |
| URL | http://hdl.handle.net/10119/12617 |
| Rights | |
| Description | Supervisor:池田　満, 知識科学研究科, 博士 |

# ePortfolio System Design Based on Ontological Model of Self-Regulated Learning

**by**

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**submitted to**
**Japan Advanced Institute of Science and Technology**
**in partial fulfillment of the requirements**
**for the degree of**
**Doctor of Philosophy**

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December, 2014

# Abstract

Self-regulated learning is defined as a process by which learners self-regulated their learning. Self-regulated learning has positive effects on learners' success in and beyond school. Self-regulated learners are aware of their knowledge and skills, and proactive in learning. Self-regulated learning plays an important role in education and knowledge sharing. Thus, fostering self-regulated learning in university is necessary. Indeed, learners need significant support to make self-regulated learning productive. Research shows that self-regulated learning skills are teachable. Learners can learn self-regulated processes from instructors and peers. In addition, self-regulated learning may be fostered by technology enhanced learning environments, such as ePortfolio platform.

However, the lack of an explicit ePortfolio model for self-regulated learning leads to challenges, such as capturing and sharing self-regulated learning principles, implementing and linking self-regulated learning processes, and measuring self-regulated learning. In addition, there is a lack of reports about the impacts of such ePortfolio models on self-regulated learning.

In this research, we use ontologies to represent an integrated model that consists of ePortfolio, competency, and self-regulated learning models. An ePortfolio system was implemented based on the model. Then, we propose, implement, and evaluate an ePortfolio-based self-regulated learning model. The experiments were performed in software engineering courses. The surveys were conducted with the Motivated Strategies for Learning Questionnaire (MSLQ). The differences in MSLQ scales between pre-test and post-test, or control group and experimental group were evaluated. The trace data of learning activity was also analyzed in order to evaluate the effects of the learning model on students' self-regulated learning.

The results indicate that students had a positive reaction to the ePortfolio system, and the system affected students' achievement and self-regulated learning positively. The proposed model for self-regulated learning handles the issues of knowledge representation and sharing in self-regulated learning area and the development of self-regulated learning skills. The findings in this research also contribute to a better understanding of the effects of ePortfolio environments on learners' self-regulated learning.

# Acknowledgments

I would like to thank my supervisor Professor Mitsuru Ikeda for his constant encouragement and kind guidance during this work.

Financially, I was mainly supported by the FIVE-JAIST dual program.

I also want to thank ePortfolio group at Hoa Sen University for helping me conduct the experiment.

I am also grateful to the reviewers, my colleagues for their constructive comments on my research.

Finally, I would like to thank my family for supporting me in hard and stressful times.

# Contents

# List of Figures

# List of Tables

# 1. Introduction

Self-regulated learners are aware of their knowledge and skills and proactive in learning. They view learning as a controllable process, accept more responsibility for the results of this process, and participate in their own learning metacognitively, motivationally, and behaviorally (Winne P. H., 2005). In process terms, self-regulation is the self-directive process that transforms learners' mental abilities into academic skill. Learning is an activity that learners do for themselves in a proactive way. Self-regulated learning is defined as a process of self-generated thoughts, feelings, and behaviors that are oriented to achieving learners' goals (Zimmerman, 2002).

Educational researchers have emphasized the importance of personal responsibility and control in acquisition of knowledge and skill. Self-regulated learning change the focus of researchers from learners' ability and environments as stable factors to the process of improving the ability and environment for learning (Zimmerman, 1990). In addition, self-regulated learning is important because an objective of education is the development of lifelong learning skills (Zimmerman, 2002). Research shows that self-regulated learning has positive effects on learners' achievement in and beyond school (Winne, 2005a; Zimmerman, 2002). Self-regulated learning skills relate to the core competencies for the 21st century, which are critical competencies for better preparing students to be effective workers and citizens in the future (Wolters, 2010).

From knowledge science perspectives, knowledge sharing is the main process in education, while learning plays a significant role in the knowledge sharing process because learning ability affects the level of internalization or absorptive capacity of the recipient. Knowledge and learning are considered as an integrated whole (Lytras & Sicilia, 2005). In their research, Yoon, Song, and Lim (2009) pointed out major factors, enablers for knowledge creation and learning to occur. For example, members' continuous learning, interactive collaborations, and reflective dialogue through the teams were critical facilitators. For enablers, such as established learning processes, supportive learning culture, and collaborative communications as characteristics of learning organizations where learning is embedded in the culture and work routines. In addition, knowledge sharing is seen as occurring through a dynamic learning process (Cummings, 2003), and a successful knowledge sharing requires an ongoing process of learning interactions, rather than just a series of communications (Szulanski, 2000).

Another perspective about the relations between education and knowledge science is academic communities should be viewed as a knowledge-based organization involved in the process of developing knowledge workers. Academic cultures need to shift from knowledge storing to knowledge sharing. Preparing students to enter learning situations of organizations may be the most important objective of higher education. This objective required an environment that encourages creativity and commitment to lifelong learning (Brewer & Brewer, 2011). In addition, research shows that learning skills are significant factors that affect knowledge sharing process (Cummings, 2003; Gupta & Govindarajan, 2000; Yoon, Song, & Lim, 2009; Szulanski, 2000).

That is why self-regulated learning plays an important role in education and knowledge sharing, and fostering self-regulated learning in university is necessary. Fostering self-regulated learning helps students not only to improve academic achievements but also to prepare important skills for workplace-based learning after graduation.

Indeed, Winne (2005a; 2010) claimed that learners need significant support to make self-regulated learning productive. Self-regulated learning is not the reliance on socially isolated methods of learning, but rather the personal initiative, perseverance, and adaptive skill. Self-regulated learners seek others' support in order to improve their learning (Zimmerman, 2002).

Fortunately, research shows that self-regulated learning skills are teachable (Zimmerman, 2002; Paris & Winograd, 2003). Learners can learn self-regulated processes such as setting goals, using strategies, and self-assessing from instructors and peers. In addition, whether self-regulated learning is viewed as teachable skills or developmental processes from experience, instructors should give learners information and environment that help them become strategic, motivated, and independent learners (Paris & Paris, 2001).

In order to teach and promote self-regulated learning a number of instructional models were developed, for instance, as summarized in (Zimmerman, 1998). These models not only share social and self-directed experiences such as modeling, strategy training, verbal tuition, and academic practice but also share the view of self-regulated learning processes involving forethought, performance, and self-reflection phases. To teach and learn self-regulated learning instructors and learners need to focus on both knowledge about self-regulated learning and self-regulated learning skills, for example, self-regulated learning models and practical skills for self-assessment.

Scaffolding is a form of assistance that enables the learners to perform tasks, attain goals that are difficult for them without the assistance. Although all learners self-regulate their learning at different levels, they may do so at irrelevant times or in ways that are less effective (Winne, 2005a). Thus, scaffolding is necessary in order to help learners improve their self-regulated learning. Scaffolding self-regulated learning may be in either face-to-face or computer-based learning environments. According to Lajoie (2005), integrating scaffolding can be provided by humans and computers, and the mix would result in more ideal learner outcomes. In addition, Devolder, Braak, and Tondeur (2012) argued scaffolding is not only the interactions between humans but also the use of technological tools, resources, and environments.

Research proves self-regulated learning may be fostered by technology enhanced learning environments (Bartolomé & Steffens, 2011; Devolder, Braak, & Tondeur, 2012). Zimmerman and Tsikalas (2005) go through three cyclical phases (forethought, performance, self-reflection) to examine which self-regulatory processes can be supported by computer-based learning environments. For example, task analysis is supported by a process visualization tool called Digital IdeaKeeper; Inquiry Island tool fosters goal setting; or iSTART is used for self-explanation and elaboration. They argued that linking the processes from the forethought, performance, and self-reflective phases is a key to developing self-regulated learning.

A powerful computer-based learning environment is ePortfolio. "An ePortfolio is the product, created by the learner, a collection of digital artifacts articulating experiences, achievements and learning" (JISC, 2008). According to Abrami, et al. (2008), ePortfolio is a promising tool for fostering self-regulated learning, it makes students think critically, and become active, independent and self-regulated learners. In addition, Bartolomé and Steffens (2011) identified three characteristics of a technology enhanced learning environment that can support self-regulated learning: ability to encourage learners to plan their learning activities, ability to allow learners to receive feedback and monitor their learning, and ability to support learners to evaluate their own learning. Hence, ePortfolio models should have the above characteristics in order to foster self-regulated learning. However, the traditional ePortfolio platforms do not explicitly foster self-regulated learning in terms of planning and self-evaluating (Bartolomé & Steffens, 2011).

ePortfolios are also valid and reliable tools for learners' learning assessment (Gadbury-Amyot, et al., 2003), especially, self-assessment, which is a critical component of self-regulated learning model. In addition, it is argued that there is not only assessment of learning but also assessment for learning. It is a process of seeking and interpreting evidence for decision where the learners are, where they need to go, and how to go there (Cordova & Perio, 2010). Thus, ePortfolios may become potential environments that foster assessment for learning; consequently, they enhance self-regulated learning.

From these perspectives, the challenges in capturing and sharing competency measuring model, self-regulated learning principles, and implementing self-regulated learning processes highlight the need for an explicit ePortfolio model for self-regulated learning.

Research shows that ontological approach is a potential approach to ePortfolio modeling (Taibi, Gentile, Fulantelli, & Allegra, 2010), and SRL principles representation and sharing (Shakya & Kumar, 2005). "An ontology is an explicit specification of conceptualization" (Gruber, 1993). Ontologies contain concepts, instance of concepts and relations among them. They are used to represent knowledge in knowledge sharing systems. The powers of ontology are the abilities to represent knowledge explicitly (concepts, properties, and constraints), to encode semantics (as relations, meta-data, and inferences), and to allow of a shared understanding of the represented formal knowledge between humans and machines (Kumar, Gress, Hadwin, & Winne, 2010).

In addition, ontology is a potential approach for modeling learning and competency. Sicilia and Lytras (2005) described ontological structures for learning modeling. Ontology was also used for competency modeling. It is important to explore the relations among competencies, a competency with activities, or a competency with its evidence in order to evaluate it better (Shavelson, 2013; Voorhees, 2001). By using ontologies the elements of competency model such as proficiency level, competency domain, evidence and activity were explicitly defined.

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 if 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 ontology-based ePortfolio model to promote SRL, develop an ePortfolio system that can handle the issues of self-regulated learning scaffolding, 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. The use of ontologies may improve the processes of modeling and sharing the knowledge and skills of 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: 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 on student learning?

We examined ePortfolio, competency, and self-regulated learning models, and systematically analyzed the synergic relations among them. These relations were modeled in an integrated ontological model by unifying common components of the sub models. An ePortfolio system was developed based on self-regulated learning theories and the proposed model. This ePortfolio system was used in designing a learning model for fostering self-regulated learning in higher education. The ePortfolio-based learning model was used in courses at a university. The surveys were conducted with the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, & McKeachie, 1991) at the beginning and at the end of the courses. The differences in MSLQ scales between pre-test and post-test, or control group and experimental group were evaluated, and the trace data of learning activity was also analysed to evaluate the effects of the learning model on students' self-regulated learning.

In this research, we introduce a novel ontology-based ePortfolio model for self-regulated learning that addresses both, the challenge of knowledge representation and sharing in self-regulated learning area and the development of self-regulated learning skills. Our approach provides ontological support for self-regulated learning strategy sharing and implementation by:

- Representing an integrated ePortfolio model and its components such as self-regulated models, competency assessment models, learning strategies, and learning resources as formal ontologies

- Sharing these ontologies directly and using them as common vocabularies and knowledge base in the ePortfolio environment

- Implementing ontological reasoning in the ePortfolio environment to support learners in planning, self-assessment, and resources selection.

- Introducing an ontology-based ePortfolio environment for practicing and linking self-regulated learning processes, and for modeling and measuring self-regulated learning.

Our research also contributes to a better understanding of the effects of ePortfolio environment on learners' self-regulated learning.

The research presented in this thesis is significant for several reasons. Firstly, we treat understanding self-regulated learning as a process of mental ontology construction, which is supported by existing learning theories. Secondly, we provide a unified ontological representation for ePortfolio, competency, and self-regulated learning models, to support the development of a conceptual model that can promote self-regulated learning. Such representation allows learners to reason about the relations among learning plans, activities, learning outcomes, and learning resources. Thirdly, we developed an approach that integrates existing models into a unified learning model. Finally, we present a tool implementation to support the methodology and to demonstrate the applicability of our approach.

The remainder of this thesis is organized as follows: in Chapter 2, we introduce background relevant to our research, self-regulated learning scaffolding, ePortfolio environment, competency assessment, and ontology approach. In Chapter 3, our ontological ePortfolio model, ontology design, system development, ePortfolio-based learning model, experimental evaluation design are presented. Chapter 4 represents the results of evaluations, followed by the conclusions, limitations, and future work are discussed in Chapter 5.

# 2. Research Background and Related Work

## 2.1. 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). Self-regulated learning is defined as a process by which learners self-regulated their learning (Zimmerman, 1990). This is a process of metacognitively, motivationally, behaviorally, and actively participate in learning of learners. Self-regulated learning processes include plan, set goals, self-monitor, and self-evaluate during the acquisition process. Self-regulated learning involves the processes of using self-regulated learning strategies, self-oriented feedback, and motivation (Zimmerman, 1990). The structure and function of self-regulatory processes are expressed in terms of three cyclical phases: forethought, performance, and self-reflection as in Figure 2.1.

In terms of learners' characteristics, self-regulated learners are aware when they know a fact or possess a skill, and they use metacognitive, motivational, and behavioral strategies to achieve their goals (Zimmerman, 1990). In terms of metacognition, self-regulated learners plan, set goals, self-monitor, self-evaluate, and self-control their learning. They also report high self-efficacy, self-attributions, and intrinsic task interest. In their behavior, self-regulated learning learners select, structure, and create environments that optimize learning. Although all learners regulate their learning at some levels, self-regulated learners are distinguished by the awareness of strategic relations between self-regulation and achievement and the use of these strategies to attain learning goals based on the feedback about learning and skill. 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).

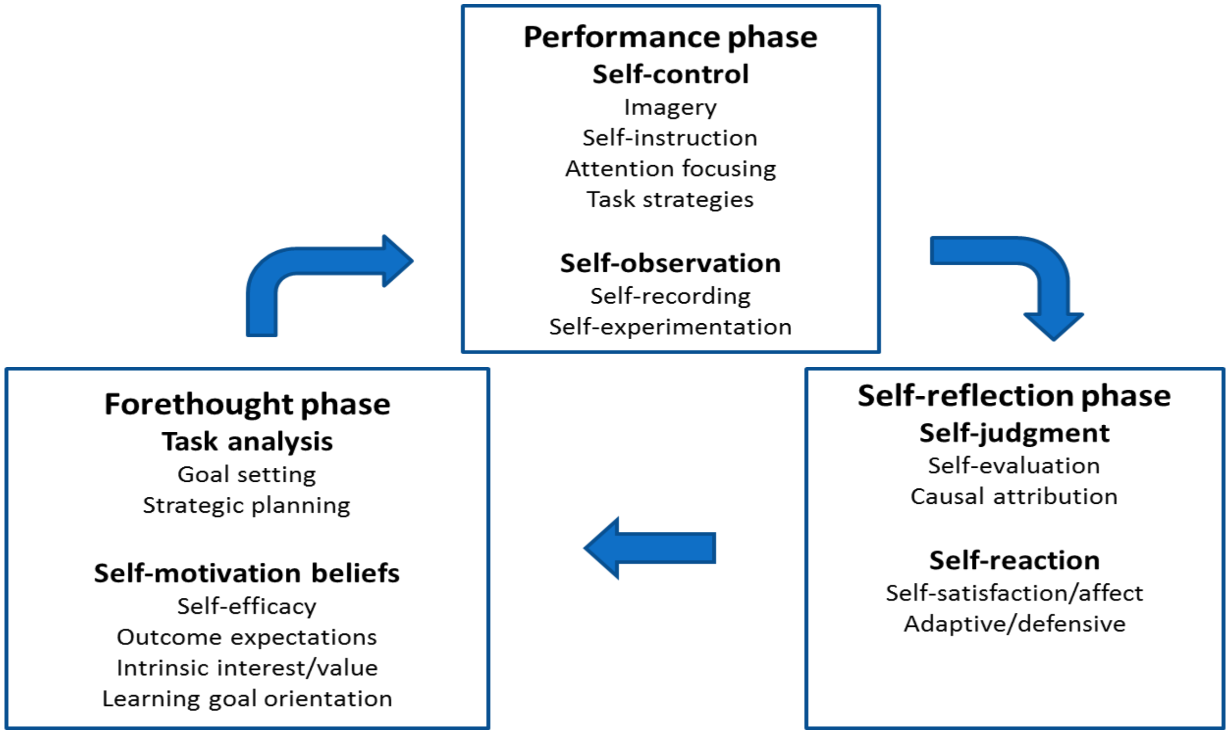



Figure 2.1 Phases and Sub-processes of self-regulated learning (Zimmerman, 2002)

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 as described in Table2.1.

According to Pintrich (2004), the self-regulated learning models share four general assumptions: the active, constructive assumption; the potential for control assumption; the goal, criterion, or standard assumption; and the mediators between personal and contextual characteristics and actual achievement or performance assumption. The framework is based on these four assumptions and more detail of how self-regulated learning operates.

### 2.1.1. Social perspective of self-regulated learning

In social cognitive theory, human behavior is motivated and regulated by the ongoing exercise of self-influence. Self-regulation includes self-monitoring of one's behavior, its determinants, and its effects; judgment of one's behavior in relation to personal standards and environmental context; and affective self-reaction. Self-regulated learning also encompasses the self-efficacy mechanism, which play a central role in the exercise of personal agency by its strong impact on thought, affect, motivation, and action (Bandura, 1991).

Table 2.1 Phases and Areas for Self-regulated learning (Pintrich, 2004).

| | Areas for regulation | | | |
|---|---|---|---|---|
| Phases | Cognition | Motivation/Affect | Behavior | Context |
| Phase 1<br>Forethought, planning, and activation | -Target goal setting<br>-Priot content knowledge activation<br>-Metacognitive knowledge activation | -Goal orientation adoption<br>-Efficacy judgments<br>-Perception of task difficulty<br>-Task value activation<br>-Interest activation | -Time and effort planning<br>-Planning for self-observations of behavior | -Perception of task<br>-Perception of context |
| Phase 2<br>Monitoring | -Metacognitive awareness and monitoring of cognition | -Metacognitive awareness and monitoring of motivation and affect | -Awareness and monitoring of effort, time use, need for help<br>-Self-observation of behavior | -Monitoring changing task and context conditions |
| Phase 3<br>Control | -Selection and adaptaionn of cognitive strategies for learning , thinking | -Selection and adaptation of strategies for managing, motivation, and affect | -Increase/decrease effort<br>-Persist, give up<br>-Help-seeking bahavior | -Change or renegotiate task<br>-Change or leave context |
| Phase 4<br>Reaction and reflection | -Cognitive judgments<br>-Attributions | -Affective reactions<br>-Attributions | -Choice behavior | -Evaluation of task<br>-Evaluation of context |
| Relevant MSLQ Scales | Rehearsal<br>Elaboration<br>Organization<br>Critical thinking<br>Metacognition | Attribution<br>Intrinsic goals<br>Extrinsic goals<br>Task value<br>Control beliefs<br>Self-efficacy<br>Test anxiety | Effort regulation<br>Help-seeking<br>Time/Study environment | Peer learning<br>Time/Study environment |

In addition, self-regulation is viewed as an interaction of personal, behavioral, and environmental processes. It is described as cyclical because the feedback from prior performance is used to make adjustments during current efforts. Because personal, behavioral, and environmental factors are changing during learning, and must be observed or monitored using three self-oriented feedback loops (see Figure 2.2). Behavioral self-regulation involves self-observing and strategically adjusting performance processes, such as a learning method. Environmental self-regulation is observing and adjusting environmental conditions or outcomes. Covert self-regulation is monitoring and adjusting cognitive and affective states (Zimmerman, 2000).

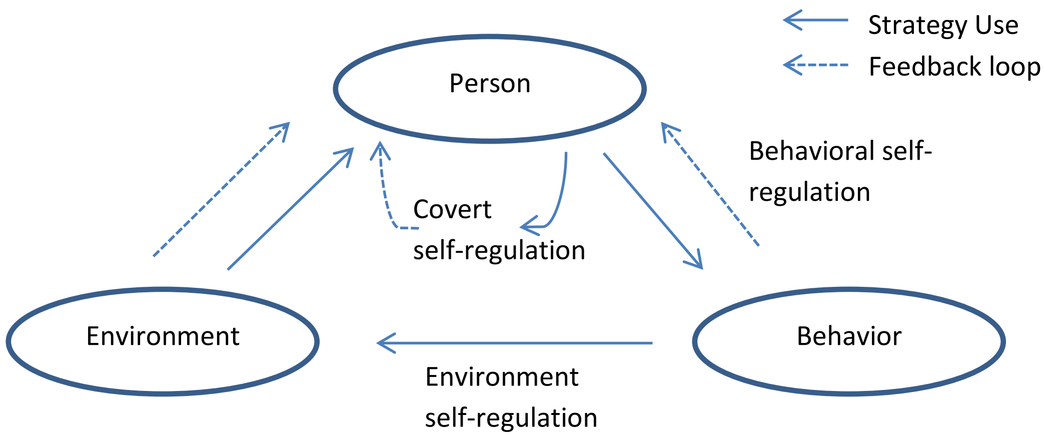



Figure 2.2 Triadic forms of self-regulated learning (Zimmerman, 2000).

### 2.1.2. The role of cognition, metacognition, and motivation

Self-regulated learning consists of three main components: cognition, metacognition, and motivation (Schraw, Crippen, & Hartley, 2006). The components of self-regulated learning are described in Figure 2.3. Cognition includes skills that enable learners to encode, memorize, and recall information. Metacognition includes skills that enable learners to understand and monitor their cognitive processes. Motivation includes beliefs and attitudes that affect the use and development of cognitive and metacognitive skills. These components may be divided into subcomponents. Cognition includes three types of learning skills: cognitive strategies, problem solving strategies, and critical thinking skills. Metacognition includes two main components: knowledge of cognition and regulation of cognition. Motivation involves self-efficacy and epistemological beliefs. Each of these components is necessary but not sufficient for self-regulated learning.

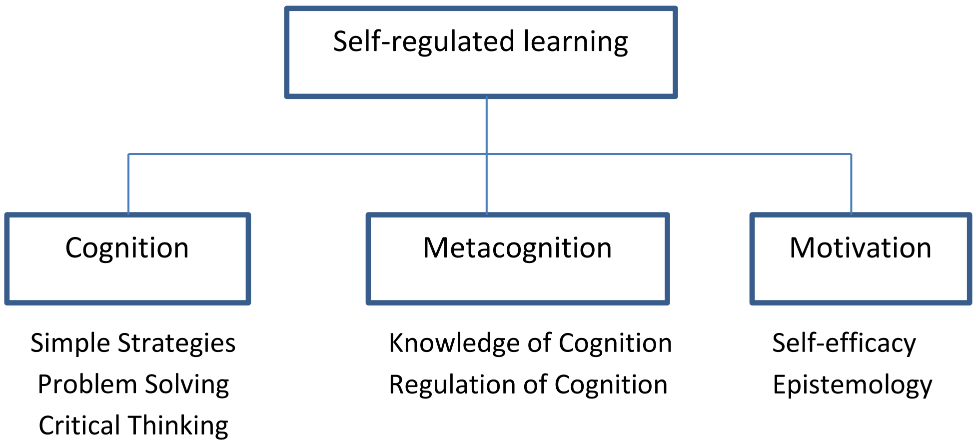



Figure 2. 3 Components of self-regulated learning (Schraw, Crippen, & Hartley, 2006).

“Metacognition” is often simply defined as “thinking about thinking.” However, in reality, metacognition is a complex concept. Metacognition refer to higher order thinking which involves active control over the cognitive processes engaged in learning. Activities such as planning how to approach a learning task, monitoring comprehension, and evaluating progress toward the completion of a task are metacognitive in nature (Livingston, 2003). Metacognition consist of both metacognitive knowledge and metacognitive experience or regulation. Metacognitive knowledge refers to acquired knowledge about cognitive processes, knowledge that can be used to control cognitive processes. It can be divided into knowledge of person, task, and strategy variables. Metacognitive experiences involve the use of metacognitive strategies or metacognitive regulation.

According to Livingston (2003), cognitive strategies are used to help a learner achieve a goal while metacognitive strategies are used to ensure that the goal has been reached. Knowledge is considered to be metacognitive if it is actively used in a strategic manner to ensure that a goal is met. Metacognition enables us to become successful learners, and has been associated with intelligence. In addition, there were empirical evidence that metacognition is teachable (Lai, 2011).

Motivation is another essential dimension of self-regulated learning. The term “motivation” can be used in different ways, but in essence it refers to any kind of general drives to do something (Baumeister & Vohs, 2007). According to Zimmerman and Schunk (2008) the learners’ motivation comes from their goal orientations, attributions, self-efficacy beliefs, outcome expectations, social sources, values, and interests. The role of motivation in self-regulated learning can be: (a) a precursor to self-regulated learning, such as individual differences in interest regarding an academic task; (b) a mediator of self-regulated learning, such as whether a training-induced motive leads to improved effort to self-regulated learning; (c) a concomitant of self-regulated learning outcomes, such as whether a learning strategy produces changes in intrinsic interest in task; and (d) a primary outcome of self-regulated learning, such as whether self-regulated learning leads to lower levels of defensiveness about taking courses in foreign language.

## 2.2. Self-regulated learning impacts

Self-regulated learners select and use self-regulated learning strategies to achieve desired academic outcome on the basis of feedback about learning effectiveness and skill (Zimmerman, 1990). They focus on how they activate, alter, and sustain specific learning practices in social as well as solitary context (Zimmerman, 2002). Self-regulated learning leads to the essential qualities for lifelong learning (Wolters, 2010; Zimmerman, 2002).

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 & Volet, 2012). Self-regulated learners tend to have high motivation and confidence in learning, and to use productive problem solving skills. Those characteristics lead to relevant behavior and also a high level of achievement (Perry & Winne, 2013). The research also revealed students' awareness of how their approach to study impacted on the quality of their learning (Warburton & Volet, 2012). The use of metacognitive learning strategies and motivation for learning increases in learning environments with self-regulated learning opportunities (Vrieling, Bastiaens, & Stijnen, 2012). In a research about the role of self-regulated learning in enhancing learning performance with 6524 students from 20 secondary schools, Cheng (2011) claimed that students' learning motivation, goal setting, action control and learning strategies played a significant role in their learning performance.

In addition, research also demonstrates the importance of self-regulated learning in different contexts, such as teacher preparation (Paris & Winograd, 2003; Vrieling, Bastiaens, & Stijnen, 2012), science education (Schraw, Crippen, & Hartley, 2006), computer science (Kumar, et al., 2005; Alharbi, Henskens, & Hannaford, 2012), online learning environment (Barnard-Brak, Lan, & Paton, 2010), and workplace learning (Siadaty, Gašević, Jovanović, Pata, & Milikić, 2012; Holocher-Ertl, et al., 2011).

Paris and Winograd (2003) explained why self-regulation is important for teachers. They argued that teaching requires problem solving and invention. Thus, nurturing teacher the capacity and skills to deal with the difficult problems of the real world is better than teaching teachers facts and rigid decision making models. Self-regulated learning provides additional insights into the issues of teaching and learning, especially, when teachers are faced with the challenges of connecting their teaching and students' learning to the reality. In addition, understanding self-regulated learning can help teachers make thinking public and visible.

The characteristics of learners who are engaged in self-regulated learning are summarized in (Montalvo & Torres, 2004): they are familiar with and know how to use cognitive strategies, which help them to attend to, transform, organize, elaborate and recover information; thay know how to plan, control and direct mental processes toward the achievement of personal goals; they show motivational beliefs and adaptive emotions, the capacity to control and modify their learning in different contexts; they plan and control the time and effort to be used on tasks, and they know how to create favorable learning environments; they show greater efforts to participate in the control and regulation of academic tasks; they play volitional strategies to avoid external and internal distraction, in order to maintain their concentration, effort and motivation while performing learning tasks.

In summary, these points explain why self-regulated learning affects students' achievements positively. Self-regulated learning research explains how self-regulated learners are successful in and beyond school. It is necessary to support instructors to provide self-regulated learning practices to learners and scaffold learners in order to develop their self-regulated learning skills.

### 2.3. Self-regulated learning instruction models

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 & Winne, 2013). Learners' development of self-regulated learning depends on support from others, for example, teachers or peers.

A key feature of a social cognitive model of self-regulation is the interdependent roles of social, environmental, and personal influences. Social and environment is viewed as resources for self-enhancing forethought, performance or volitional control, and self-reflection. Modeling and instruction serve as a primary vehicle that socially conveys self-regulation skills, such as persistence, self-praise, and adaptive self-reactions to learners (Zimmerman, 2000).

In order to teach and promote self-regulated learning in school settings, 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.

Graham, Harris, and Troia (1998) described the stages and characteristics of instruction in a framework for self-regulated strategy development. According to them, there are six stages of self-regulated strategy development: develop background knowledge, discuss it, model it, memorize it, support it, and independent performance. In addition, the characteristics of self-regulated strategy development instruction include interactive learning between teacher and students, individualization, criterion-based instruction, and ongoing strategy development.

Paris and Winograd (2003) offered a list of guidelines for enhancing self-regulation for teachers and students. First, self-assessment leads to a deeper understanding of learning. When self-assessing, analyzing personal learning styles and learning strategies, and comparing them with others, increase awareness of different ways of learning. Evaluating what was known and what was not known, as well as knowing personal depth of understanding about key points, promotes efficient effort allocation.

In addition, periodic self-assessment of learning processes and outcomes is a useful habit to develop because it promotes monitoring of progress, stimulates repair strategies, and promotes feeling of self-efficacy. Second, self-management of thinking, effort, and affect promotes flexible approaches to problem-solving that are adaptive, persistent, self-controlled, strategic, and goal oriented. Indeed, setting appropriate goals that are attainable is most effective. Managing time and resource through effective planning and monitoring is essential to setting priorities, overcoming difficulty, and persisting to task completion. In addition, reviewing one's own learning, revising the approach, or even starting a new, may indicate self-monitoring and a personal commitment to high standards of performance. Third, self-regulated can be taught in diverse ways. Self-regulated learning can be taught with explicit instruction, directed reflection, and metacognitive discussions. Self-regulated learning also can be promoted indirectly by modeling and by activities that entail reflective analyses of learning. In addition, self-regulated learning can be promoted by assessing, charting, and discussing evidence of personal growth. Finally, self-regulation is embedded into the experiences and the identity of each individual. How individuals choose to assess and monitor their own behavior is usually consistent with their identity. Teachers reflect on their own learning and teaching experience in order to achieve insight into their thinking and pedagogy. Finally, participation in a reflective community enhances the frequency and depth of examination of one's self-regulated learning habits. In order to foster self-regulated learning, we should create the environment in which students and teachers can engage in the above principles of self-regulated learning.

More specifically, Montalvo and Torres (2004) identified the common points of self-regulated learning teaching models as follows: direct teaching of strategies, modeling, guided and autonomous practice using strategies, feedback, self-observation, social support and withdrawal at the moment when the student has reached a certain degree of responsible participation, and self-reflection. They also pointed out some main directions the research should focus to improve self-regulated learning teaching, for example, improving the definition and making more operational the main processes and activities involved in self-regulated learning, development of more complete model, perfecting measuring instruments, and the teaching of processes in self-regulated learning within different areas of the curriculum. In addition, the authors summarised six strategic areas in self-regulated learning teaching. They are inquiry based learning, the role of collaborative support, strategy instruction, strategies for helping students construct mental models and to experience conceptual change, the use of technology, and the impact of student and teacher beliefs.

Perry and Winne (2013) argued that to support their students' self-regulated learning teachers should: first, design learning experiences to provide opportunities for practicing each phase of SRL; second, offer choices about what, who, where, when, and how to work on task; finally, model thinking and problem solving strategies for them and arrange varied and frequent opportunities for feedback. In addition, to create a self-regulated learning model for primary teacher Vrieling, Bastiaens, and Stijnen (2010) proposed seven process-oriented design principles: knowledge building, meta-cognition and content matter, modeling skills, scaffolding, conditions, collaboration and learning task.

From the social-cognitive perspectives of self-regulated learning, individuals learn to become self-regulated by advancing through four levels of development: observational, imitative, self-controlled, and self-regulated levels (Schraw, Crippen, & Hartley, 2006). In addition, Vockell (2008) described the steps learners typically go through when they learn metacognitive skills. They establish a motivation to learn, focus their attention on what it is that they or someone else does that is metacognitively useful, talk to themselves about metacognitive process, begin to use the process without even being aware that they are doing so.

The literature shows that to teach and learn self-regulated learning we need to consider about both knowledge about self-regulated learning such as self-regulated learning models, and self-regulated learning skills such as practical skill for self-assessment. Paris and Winograd (2003) claimed that understanding the notions of self-regulated learning enhances teachers' ability to be reflective. Perry and Winne (2013) viewed self-regulated learning as a skill. Developing and improving skills call for extensive, deliberate practice. To develop this skill learners have two key tasks: identify, then apply tactics and strategies for learning; and examine how well a tactic or strategy worked, and plan what to do next.

In addition, Romiszowki (2009) argued that skill is something that develops with experience and practice. The learning process for skills requires repeated and appropriate practice. The appropriate utilization of the knowledge base may involve the use of other supplement skills (e.g., critical thinking) and knowledge (e.g., problem-solving heuristics) that are necessary for the internal planning or control of the task. These meta-skills and meta-knowledge elements are internal and not directly observable, but the skilled activity is performed. Skilled activity can and should be self-evaluated by the owner. This process is called reflection**.** The more knowledge-dependent is the skill, the greater is the importance of reflection for its development. Self-regulated learning is a knowledge-based skill, thus we should focus on improving self-reflection in order to enhance self-regulated learning.

Tillema and Kremer-Hayon (2002) noted that what teachers themselves are doing in terms of self-regulated learning does not align with what they are teaching others to do, they struggled with both learning to use self-regulated learning approaches themselves, and teaching student to use self-regulated learning. Thus, practicing what will be taught about self-regulated learning is necessary. It means that we should apply self-regulated learning in teaching student about self-regulated learning. In addition, talking about self-regulated learning and helping teachers to develop practices promote self-regulated learning (Perry, Hutchinson, & Thauberger, 2008).

In summary, the research shows that self-regulated learning is teachable and can be fostered. It is necessary to scaffold teachers and learners in order to improve the knowledge about self-regulated learning and practical skills. In addition, the potential and the need of computer-based support systems emerge in the field of teaching and fostering self-regulated learning. The next section shows the background of self-regulated learning scaffolding. We also focus on the use of technology to promote self-regulated learning.

### 2.4. Self-regulated learning scaffolding

A key feature of a social cognitive model of self-regulation is the interdependent roles of social, environmental, and personal influences. Social and environment are viewed as resources for self-enhancing forethought, performance or volitional control, and self-reflection. Modeling and instruction serve as a primary vehicle that socially conveys self-regulation skills, such as persistence, self-praise, and adaptive self-reactions to learners (Zimmerman, 2000). According to Zimmerman, individuals learn to become self-regulated by advancing through four levels of development: observational, imitative, self-controlled, and self-regulated levels. Learning at the observational level focuses on modeling, whereas learning at the imitative level focuses on social guidance and feedback. At controlled level, learners construct internal standard for acceptable performance and become self-reinforcing via positive self-talk and feedback. At the self-regulatory level, learners have strong self-efficacy beliefs and cognitive strategies that allow them to self-regulate their learning. In addition, learning depends on an interaction among external environmental factors and the students' knowledge, skills as well as interactions between students, and between students and the instructor. Therefore, different learning environments may support different outcomes related to self-regulated learning (Stefanou, Stolk, Prince, Chen, & Lord, 2013).

Based on the previous sections, it is argued that we should enhance knowledge about self-regulated learning and improve practical skills that relate to self-regulated learning in order to foster self-regulated learning. For the knowledge about self-regulated learning, we should consider about how to represent the principles, processes, components, and strategies of self-regulated learning in effective ways, in which it is easy to understand, use, and share them. For practical issues, tools or environments should be provided for practicing self-regulated learning processes, for example, planning, monitor and control, self-reflection, and especially, the sub-processes of evaluation.

A scaffold is a temporary entity that is used to reach one's potential and then removed when learners demonstrate their learning (Lajoie, 2005). In particular, ''scaffolding'' describes how teachers provide and adjust support for learning and self-regulated learning. Scaffolding is based on the assumption that students learn to regulate their behavior by first being regulated by others. Modeling, guidance, and elaborative feedback are parts of scaffolded instruction that foster students' development of self-regulatory skills. In addition, the supportive environment that is used for scaffolded instruction enhances students' expectations for success, and encourages their engagement and persistence in learning (Perry, Hutchinson, & Thauberger, 2008).

Scaffolding may be provided with the use of computers. For example, by sharing the self-regulated learning model through software systems, computers foster understanding about self-regulated learning in the users. Computer systems would be able to link learners to peers and tutors who would be ready, willing, and able to help the learners. According to Lajoie (2005), integrating scaffolding can be provided by humans and computers, and the mix would result in more ideal learner outcomes. In addition, Devolder, Braak, and Tondeur (2012) agreed scaffolding is no longer restricted to interactions between humans; such interactions have been extended to include the use of technological tools, resources, and environments.

Lajoie (2005) expressed the roles of dialogue and social interaction in educational scaffolding, such as comprehension and monitoring activities, student self-explanations, instruction, cognitive scaffolding, motivational scaffolding, and tutor question-asking. Devolder, Braak, and Tondeur (2012) explained how technologies can scaffold self-regulated learning base on integrated framework of self-regulated learning in (Pintrich, 2004).

Self-regulated learning skills may be fostered by technology enhanced learning environments (Bartolomé & Steffens, 2011; Devolder, Braak, & Tondeur, 2012; Steffens, 2001). More specifically, computer-based learning environments can be used as self-regulatory tools to enhance learning (Zimmerman & Tsikalas, 2005). In addition, from constructivist assumptions, instructional system technology would be a negotiating tool for guiding learners during learning processes and for self-evaluation of learning outcome (Jonassen, 1991). For example, 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).

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 & 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. Zimmerman and Tsikalas also argued that a key to developing self-regulated learners is linking the processes from the forethought, performance, and self-reflect phases. This means computer-based learning environments that support self-regulatory processes in all three phases are more likely to support SRL better. However, the literature does not report any model or tool that can fully handle these issues.

Another aspect of computers enhance self-regulated learning is online measures of self-regulated learning with computer traces (Zimmerman, 2008). These online measures show how learners become masters in learning. From this perspective, computer based environments show potential for fostering the uses of self-regulated learning. For examples, a system to support the recording of activity data, and then enhances self-regulated learning measuring was introduced (Perry and Winne, 2006).

However, in the publication about the key issues in modeling and applying research on self-regulated learning Winne (2005) argued that we have lacked tools for gathering data that are critical to mapping events that constitute self-regulation. That data and tools are very important for evaluating and modeling self-regulated learning. Another important point is most of the computer-based learning environments do not explicitly address motivational aspects of self-regulation (Zimmerman & Tsikalas, 2005).

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 & Steffens, 2011; Abrami, et al., 2008).

### 2.5. ePortfolios

A portfolio is defined as a purposeful collection of student work that demonstrates the students' efforts, progress, improvement, and achievements (Paulson, Paulson, & Meyer, 1991; Barrett, 1998). Our research focuses on electronic portfolios (or ePortfolios), which seem to be focused widely and are more flexible. In addition, by using technology to store student portfolios, we can make their work portable, accessible, more easily and widely distributed. Users can also replay performance works anytime.

From the definitions of portfolios, an ePortfolio is defined by JISC as the product, created by the learner, a collection of digital artifacts articulating experiences, achievements and learning (JISC, 2008). Lorenzo and Ittelson (2005) defined an ePortfolio is a digitized collection of artifacts, including demonstrations, resources, and accomplishments that represent an individual. Paulson, Paulson, and Meyer (1991) noted ePortfolios should include evidence of student self-reflection and become an intersection of instruction and assessment. They also argued that ePortfolios have potential to reveal a lot about their creators, can help instructors and students understand the educational process at the individual level, and encourage students to take charge of their own learning.

According to Lorenzo and Ittelson (2005), there are three broad categories of ePortfolios: student ePortfolios, teaching ePortfolios, and institutional ePortfolios. They have six main functions, which are: planning educational programs; documenting knowledge, skills, abilities, and learning; tracking development; finding a job; evaluating; and monitoring and evaluating performance. These types and functions are combined with each other to create ePortfolio models.

ePortfolio-based learning was explored in (JISC, 2008). According to this report, ePortfolio development can improve understanding of the self and the curriculum, engage and motivate learners, both individually and as part of a community of practice, personalize learning, support models of learning appropriate to a digital age, and promote reflective practice. O'Keeffe and Donnelly (2013) explored ePortfolios' capacity for adding value, deepening student learning, and fostering creativity. In addition, a research shows a critical ability of ePortfolios that is capturing pedagogical knowledge (Parkes, Dredger, & Hicks, 2013). The authors claimed that an ePortfolio is not only as a collection of artifacts but also as a pedagogical space where teaching and learning are as transparent as possible. This conclusion is important for our research because one of our objectives is finding the way to capture, share and promote self-regulated learning.

In order to support realizing the power of ePortfolios, a list of guidelines was offered (Paulson, Paulson, & Meyer, 1991). They are: 1) ePortfolios must contain information that shows that a student has engaged in self-reflection; 2) ePortfolios offer a concrete way for student to learn to evaluate their own work; 3) ePortfolios is separate and different from cumulative evaluation; 4) ePortfolios must convey explicitly or implicitly the students' activities; 5) ePortfolios may serve different purpose, but these must not conflict; 6) ePortfolios should illustrate growth; and 7) students must be supported when using ePortfolios.

In summary, ePortfolio is potential platform for fostering student learning. We should improve ePortfolios' capacity for measures of learning processes, social aspects, and knowledge capturing and sharing.

### 2.6. Competency modeling and measuring in learning

Competency modeling and measuring play an important role in learning. Indeed, the objective of learning is achieving competencies. In other words, a learning activity occurs when people want to acquire new competencies (Sicilia, 2005). Thus, evaluating competencies is evaluating learning outcomes, and vice versa (Voorhees, 2001).

In (Sadler, 2013) the author points out the differences between competency and competence, according to him; competency means an identifiable skill or practice while competence consist of a number of competencies. A definition of competency cited in (Voorhees, 2001), a competency is a combination of skills, abilities, and knowledge needed to perform a specific task. Sometime, the words competency and competence mean basically the same thing. In this research, particular competency is known as knowledge or skill which needed for or acquired during learning activities.

Addition, Pfadenhauer (2013), argued measures of competency must include the social aspects of competency, or Gulikers and Mulder (2013) proposed modeling and measuring competency must consider about actors' actions, their reflection on performance and their evaluation. Consistent with these ideas, competency model in (Shavelson, 2013) has six facets: complex physical and/or intellectual skills, observable performance, standard criteria for evaluation, real-life situations, level of performance, and improvement through education and practice.

In other words, research shows that modeling and measuring competency in learning should take into account peer and self-assessment, and base on a process perspective, it means consider on activities and the results of activities.

Voorhees (2001) argued that competency should be defined explicitly and it is the central element of learning modeling. He supported the assessment strategies that are based on smaller units of analysis, such as activities, not course level as the traditional models. In competency-based learning model, learning can be described and measured in ways that are understood by all stakeholders. Competencies represent the ways in which students approach their goals, while the assessments of competencies are used in making decisions about using learning strategies to improve learning. In addition, Voorhees claimed that a common language for competency modeling and new ways to store and represent students' competency levels can promote learning.

Sicilia (2005) assumed that learning occurs when people want to acquire new competencies. Thus, it is necessary to define learning processes by intended competencies. Sicilia provided an organizational view of learning processes by using semantic web technologies with two main elements: competencies and learning objects. A workflow based competency model was introduced (Macris, Papadimitriou, & Vassilacopoulos, 2008). The authors assumed that a business process contains some activities, and each activity needs some required competencies in order to perform it well. According to them, a role in organization can be defined by its required competencies, and task assignment will be performed by competency gap analysis. From these perspectives, we can map them to learning setting, in which learning involves learning activities; and each activity requires some prerequisite competencies and creates some goal competencies. Thus, learners can set learning goals and select learning activities based on competency gap analysis.

In addition, Karetsos and Haralambopoulos (2011) posed the main requirements of a competency model, such as specifying learning objectives in an explicit way with a structure that can be understood and processed by computers, ability to assess competency gap, and allowing competency subsumption. In their model, learners, activities, learning objects, and competencies are linked. For example, a student performs an activity; this activity has prerequisite and outcome competencies. They also proposed the assessment entity of competency but did not describe the details or show how to assess competencies.

Overall, this section shows that competency is an important element in learning design; to evaluate competencies we must consider the evidence of these competencies, which are the created artifacts and processes of achieving and using the competencies.

## 2.7. Ontology

In philosophy, it means theory of existence. It tries to explain what exist in the world and how the world is configured by introducing a system of critical categories to account things and their intrinsic relations (Mizoguchi, 1998).

"An ontology is an explicit specification of conceptualization" (Gruber, 1993). According to Gruber, ontologies contain concepts, instances of concepts, and relations among them; and they are used to represent knowledge in knowledge sharing systems. Gruber (1995) argued that agents exchange knowledge need three levels: representation language format, agent communication protocol, and specification of the content of shared knowledge. He also claimed that ontology commitments are agreements to use the shared vocabulary in a coherent and consistent manner.

From knowledge-based systems perspective, ontology is defined as “a theory (system) of concepts/vocabulary used as building blocks of information processing system” (Mizoguchi, 1998). The author also proposed three levels of ontologies: level 1, a structured collection of terms, which is a is-a hierarchy among concepts; level 2, in addition to the contents of level 1 ontology, we can add formal definitions of concepts, relations, and constraints; level 3, the ontology is executable, and can answer questions about the runtime performance of the models. In addition, Mizoguchi and Bourdeau (2000) argued that using ontological engineering can overcome common problems in artificial intelligence in education. According to the authors, at level1 ontology provides a set of terms, which should be shared among people as well-structured shared vocabulary. These terms enable us to share the specifications of domain and teaching and learning strategies. At level 2, ontology represents the conceptualization declaratively. Thus, it is the source of intelligence of an ontology-based system. Another important role of ontology is meta-model. A model usually built in the computer as an abstraction of the real target. An ontology provides concepts and relationships which are used as building blocks of the model. Ontology specifies the models to build by giving the guidelines and constraints that should be satisfied. In addition, a shared ontology is a first step towards standardization. By using ontologies, concepts and the knowledge of a domain can be systematized in terms of the concepts and standardized relationships identified in the ontology. Thus, ontologies can improve the abilities to understand the theories of the systems.

In artificial intelligence theories, ontologies are content theories about the sorts of objects, properties of objects, and relations between objects that are possible in a specified domain of knowledge (Chandrasekaran, Josephson, & Benjamins, 1999). There are two senses of ontology. First, ontology is a representation vocabulary, often specialized to some domain or subject matter. Second, the term ontology is used to refer to a body of knowledge describing some domains, using a representation vocabulary. The authors also explained why ontologies are important. According to them, ontology can be vocabulary for representing knowledge; it works for coherent reasoning purposes. Ontologies enable knowledge sharing. Suppose we perform an analysis and create ontologies for some area of knowledge. Then, we can share these ontologies with others who need them to avoid the repeated works. Shared ontologies let us build specific knowledge bases that describe specific situations. We can use the terms provided by ontologies to assert specific propositions about s domain or a situation in a domain.

In addition, an ontology provides a common vocabulary and a frame of reference that can enhance the communication and sharing of ideas among practitioners (Holsapple & K.D.Joshi, 2004). More technologically, ontology approach is a potential for semantic modeling, distributing data across the web and merging data from multiple sources (Allemang & Hendler, 2011). The use of ontologies and semantic web tools provides software systems with ability to infer more conclusions from an existing knowledge base. The power of ontologies is the abilities to represent knowledge explicitly (concepts, properties, and constraints), to encode semantics (as relations, meta-data, and inference), and to allow for a shared understanding of the represented formal knowledge within and between humans and machines (Kumar, Gress, Hadwin, & Winne, 2010).

Ontological engineering involves a set of activities conducted during conceptualization, design, implementation and deployment of ontologies (Devedzic, 2002). Devedzic argued modeling and metamodeling are useful to ontological engineering at the specification and conceptualization level. They help organize the knowledge acquisition process; specify the ontlogy's objective, scope; and build its inittial vocabulary and organize taxonomy in an informal or semiformal way. Ontologies are specific, high-level models of knowledge underlying all things, concepts, and phenomena. Ontological engineers often represent concept hierachies and taxonomies in layers, and use graphs to visually enhance the representation of models of the relevant world. In addition, an ontology is a metamodel describing how to build models. Its concepts and relations are used as building blocks when modeling parts of the domain knowledge.

### 2.7.1. Ontology and competency modeling

It is important to explore the relations among competencies, a competency with related activities and a competency with its evidence. This information makes competency assessments more reliable (Shavelson, 2013; Gulikers & Mulder, 2013; Voorhees, 2001).

An ontological approach improves the ability to specify competency models, in which we explicitly define the elements and relationships among them in competency models. For example, the concepts are competency domain, proficiency level, evidence, or activities; and the relationships are the relations between evidence and a competency or between required and outcome competencies. Then, we use the models and reasoning ability of ontology and semantic web technologies to develop systems that support competency assessment processes. Because ontological approaches provide common vocabularies for creating a standard competency model, which promotes exchange of competencies among systems, sharing information and understanding about competencies among agents.

Sicilia (2005) proposed ontological approaches to competency gap analysis and learning activity selection. The workflow based competency ontologies were proposed (Macris, Papadimitriou, & Vassilacopoulos, 2008). These authors assumed that a business process contains some activities and each activity needs some required competencies in order to perform it well. From this perspective, a role in organization can be defined by its required competencies, and task assignment will be performed by competency gap analysis. In addition, another ontology-based competency model was proposed (Schmidt & Kunzmann, 2006). This model is used in combination of competency management and technology-enhanced workplace learning. The authors also introduced some key concepts in a high-level ontology, such as competency, evidence, and instructional entity. They indicated some important relationships among these concepts, such as competency has evidence, instructional entity has objective competency, and instructional entity has prerequisite competency.

An ontology for modeling competency, which combines the concepts of knowledge, skill, attitudes, and performance was proposed (Paquette, 2007). Paquette argued that to facilitate the uses of competencies in education and training we should improve competency representation beyond the textual statement, for example, giving semantic meaning to the relations of competencies, improving structural representation of knowledge in activities and resources, and providing a quantitative metric for evaluating competency gaps.

In addition, Karetsos and Haralambopoulos (2011) proposed an ontology-based framework that supports teachers to construct learning designs. They set main requirements of a competency model, such as descriptions of learning objectives in an explicit way that can be understood and processed by computers. In addition, the abilities to assess competency gaps and allow competency subsumption were claimed also. In their proposed competency model, they establish the connections between learners, learning objects, activities, and competencies. For example, a student performs an activity; an activity has prerequisite and outcome competencies. They also proposed assessment entity of competencies, but did not describe the details and did not show how to assess these competencies.

### 2.7.2. Ontology and ePortfolio

Ontologies also are used to model ePortfolios. In a study (Taibi, Gentile, Fulantelli, & Allegra, 2010), the authors proposed a semantic web approach to learner profile modeling in a software platform. In particular, they proposed an ontology for students' competencies modeling. This ontology specifies people, their relationships, and their learning portfolios. It is a fundamental layer for a learning environment, in which students' informal learning activities carried out in social networks are managed and evaluated.

Lougheed, Bogyo, and Brokenshire (2005) argued that proper design and implementation of an ePortfolio system could solve the problems of ePortfolios, such as inconsistence in structures. They proposed an ontological approach for formalizing ePortfolios in the ePortfolio tool. According to them, the ontology has some main elements, such as portfolio types, portfolio processes, authors, and artifacts.

In addition, Wang (2009) proposed an ontological model of ePortfolios for integrated reflection. The model is a synthesis of the ePortfolio artifact categories, such as learning subject, learning objective, student work, assessment, and reflection model.

An ePortfolio is a potential platform for competency assessment. Thus, it is necessary to develop an ePortfolio model for competency assessment. Ontology approaches and semantic web technologies can be used for modeling in order to improve the ability to assess competencies via ePortfolios.

### 2.7.3. Ontology and scaffolding learning

The use of ontology is a potential approach for learning modeling. Sicilia and Lytras (2005) described ontological structures for generic constructivist and social-cultural learning framework. These structures are used as basic for learning modeling. According to the authors, specifying and sharing learning approach is important, and using ontology was common practice. Making explicit the assumptions of underlying learning theories provide a number of potential benefits for instructors and learners, such as the linking of theoretical assumptions to practical learning designs for informative purposes, tracing to the sources of the decision-making in the processes of learning, and an important source for scientific inquiry. The explicit assumptions may lead to finding patterns in design situations, useful information to inform new designs or to build decision-aid tools. Other researchers also showed the use of ontologies for modeling and sharing knowledge in learning, for example, an ontology of learning object repository was created for sharing pedagogical knowledge (Wang S. , 2008)**,** or ontologies were used to capture domain knowledge in order to support teaching programming languages (Ganapath, Lourdusamy, & Rajaram, 2011).

In self-regulated learning, Shakya and Kumar (2005) showed that we can represent and share the principles of self-regulated learning in an ontological framework by modeling the tactics and strategies of self-regulated learning models. In addition, a model for socially enhanced self-regulated learning was suggested (Siadaty, et al., 2008). Siadaty, et al., used ontologies to integrate self-regulated learning model into socially enhanced learning model to propose a framework that can foster self-regulated learning.

Ontologies also foster self-regulated learning in other perspectives. For example, the use of ontologies for integrating and sharing data in a system that supports users to trace learning activities, using ontologies to create reusable knowledge objects for fostering self-regulated learning in the workplace (Siadaty, Gašević, Jovanović, Pata, & Milikić, 2012).

Kumar, Gress, Hadwin, and Winne (2010) offered a solution, which encourages students to record and share their learning interactions using the ontology based software tool. By using the ontology based tool students can observe not only the products of their learning but also the process of how they learn. The ontological recordings of learning interactions allow educators to observe how learners learn and provide opportunities for learners to reflect on their learning processes. The system autonomously analyzes students' learning and actively promotes self- and co-regulation among learners. In addition, ontologies promote reflection, motivation for sharing knowledge, setting and monitoring goal in workplace learning by providing ability to integrate the data about a user's activities and knowledge objects from different sources (Siadaty, et al., 2011).

# 3. Research Methodology

## 3.1. The relations among ePortfolio, competency, and self-regulated learning

The literature shows that ePortfolio, competency measuring, and self-regulated learning are related to each other. For example, competency modeling and measuring affect self-regulated learning (Zimmerman, 2002; 2008; Voorhees, 2001), ePortfolios improve competency modeling and measuring (Gadbury-Amyot, et al., 2003; Parkes, Dredger, & Hicks, 2013; Rao, et al., 2012), and ePortfolios are potential environment for practicing skills related to self-regulated learning (Perry & Winne, 2013; Hadwin, Oshige, Gress, & Winne, 2010; Ryan & Ryan, 2012; Abrami, et al., 2008). Overall, ePortfolios may improve competency measuring, and then both ePortfolios and competency measuring may promote self-regulated learning.

The above points of view lead to an assumption: by embedding these components into a unified environment, self-regulated learning may be fostered. An ontological integrated model was proposed. The next sections, we discuss more about the relationships among ePortfolio, competency measuring and self-regulated learning. The relationships are the basic of proposed model.

### 3.1.1. 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.

In learning, assessment is not just for measuring but also for encouraging. According to this research (Thomas, Martin, & Pleasants, 2011) self and peer assessment can encourage students' future learning. Liu and Carless (2006) examined the role of peer feedback and its potential for encouraging student learning, they proposed peer feedback integrated with peer assessment, and creating course context for peer feedback. Liu and Carless argued assessment which supports both learning and measurement. Students not only learning from feedback but also from meta-processes like reflecting on feedback.

The scholars argued that we should carefully examine the actors' actions, perspectives, and reflection on their performance in order to model and measure their competencies (Pfadenhauer, 2013; Gulikers & Mulder, 2013). Pfadenhauer argued competency measuring should involve a dialogue with learners, and learners should have the decisive vote in determining whether or not they possess a competency or not. In addition, Voorhees (2001) addressed that the processes and results of learning activities should be included in order to measure the competencies. These points of view are related to self-regulated learning directly. Thus, competency assessments may affect self-regulated learning processes.

In addition, 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.

### 3.1.2. ePortfolios improve competency measuring

An ePortfolio is a collection of digital artifacts which show the experiences or abilities of the author (JISC, 2008). Evidence shows that ePortfolio provides a significant approach to competency modeling and measuring (Gadbury-Amyot, et al., 2003; Parkes, Dredger, & Hicks, 2013; Rao, et al., 2012). Indeed, ePortfolios store all students' achievements, and the processes that show how students reach those achievements (JISC, 2008), it means that ePortfolios contain and show not only students' competencies but also the evidence of these competencies. That is why using ePortfolio can improve the accuracy of competency assessment. In addition, ePortfolios can serve as a valid and reliable measure for assessing student competency (Gadbury-Amyot, et al., 2003).

In education, ePortfolios are used to support assessment. 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 & Hanft, 2011). ePortfolios contain evidence of competencies, which are achieved during learning. Evidence includes artifacts that were created as output of learning activities and processes that show how learners achieved the competencies.

ePortfolio systems are assessment tools, which can store, visualize evidence, and provide features for evaluation operations. O'Keeffe and Donnelly (2013) claimed ePortfolios enhance assessment and feedback, and foster creativity. 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.

In addition, Paulson, Paulson, and Meyer (1991) argued that ePortfolios are used for both instruction and assessment. Storing and representing competency evidence are the main functions of ePortfolios. According to them, ePortfolios have ability to reveal a lot information about their owners. They can help instructors and learners understand the learning processes of learners, and then encourage learners in self-assessment.

It is argued that competency evidence is the activities carried out by a learner and their results. Indeed, the processes of achieving or using competencies and artifacts created in these processes help evaluators to understand about learners better, and then they will have better judgments on learners' competencies. We propose the use of ePortfolio systems to capture, represent and observe the activities and their outcomes in order to support competency evaluation. The idea is supported by related research (Gadbury-Amyot, et al., 2003; Parkes, Dredger, & Hicks, 2013;

Rao, et al., 2012). The research showed that ePortfolio systems are relevant for competency assessment. In addition, it is desirable to have a common standard for unifying the representations of competencies in lifelong learning (Taibi, Gentile, Fulantelli, & Allegra, 2010; Lougheed, Bogyo, & Brokenshire, 2005). We argued that the combination of ePortfolios and competency models could cover the gaps of the competency models as expressed before and propose a reasonable model for measuring competency.

According to the above analysis, ePortfolios are reasonable environments for modeling and measuring competencies. ePortfolios provide competency models, tools for measuring, and evidence for competency assessment. We believe that an ePortfolio not only supports evaluators to evaluate learners' competencies more accurately but also helps them to improve evaluation skills.

### 3.1.3. ePortfolios foster self-regulated learning

With the ability to trace learning processes, ePortfolios allow learners to monitor their learning better. Another nature of ePortfolios is reflection (JISC, 2008). Reflection and evaluation play important roles in self-regulated learning, because self-regulation is based on self-reflection and self-evaluation (Zimmerman, 2002). That is why ePortfolio systems are relevant environments for reflection and collaboration between students and peers, or students and teachers (Ryan & Ryan, 2012). Indeed, learners can review, evaluate their performances during learning processes by observing what the ePortfolios captured, and then make changes to the learning strategies in order to reach the goals. In general, this methodology of learning aligns with the theory of self-regulated learning.

These advantages allow learners to use ePortfolio systems as a platform for practicing self-regulated learning processes through the self-regulated learning phases. This ability is very important in fostering self-regulated learning (Hadwin, Oshige, Gress, & Winne, 2010; Perry & Winne, 2013). Rao, et al., (2012) addressed the use of ePortfolios to provide methods for tracking performance during learning and provide aggregate data for education and performance improvement. In addition, Parkes, Dredger, and Hicks (2013) showed that students can demonstrate reflective practice and growth in learning by using ePortfolios.

Other features of ePortfolios are representation, and cooperation (JISC, 2008), learners can show their results to the 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 (Vockell, 2008; 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. These relationships are modeled in Figure 3.1.

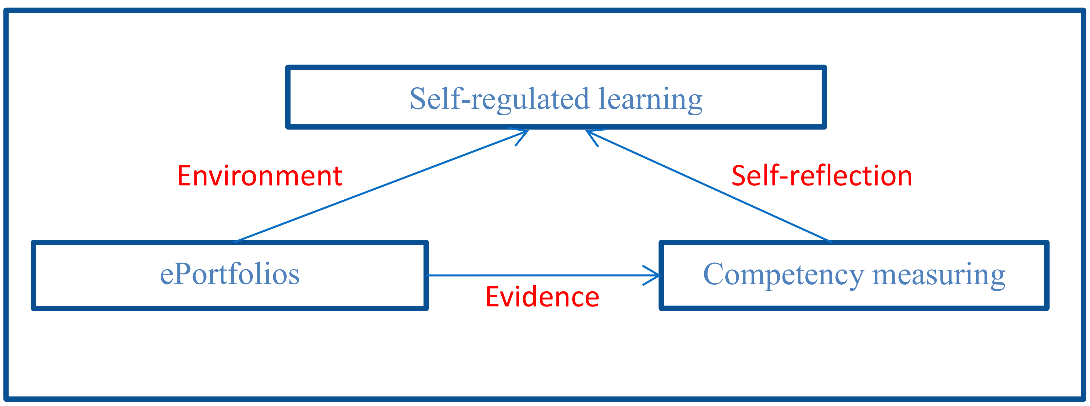



Figure 3.1 The relationships among ePortfolios, competency measuring and self-regulated learning.

### 3.2. Integrated model to promote self-regulated learning

From the relations among ePortfolios, competency measuring, and self-regulated learning in Figure 3.1, the abstract representations of them works as a conceptual model for building an integrated model that self-regulated learning. The conceptual model leads to a hypothesis: integrating these models into a unique model may foster self-regulated learning. In other words, integrating ePortfolios, competency assessment, and self-regulated learning into a platform may foster self-regulated learning because of the support from ePortfolios.

### 3.2.1. ePortfolio model

Based on the definitions of ePortfolios in (JISC, 2008) and ePortfolio formalization in (Lougheed, Bogyo, & Brokenshire, 2005), `Artifact`, `Activity`, and `Author` are the key components of an ePortfolio. ePortfolios capture learning processes and artifacts to represent competencies of their owners – the learners. Thus, `Competency` is another component embedded in the nature of an ePortfolio. In addition, this point of view is consistent with the IMS ePortfolio specification (IMS, 2005). In this research, we expanded the descriptions of these components in order to create an ePortfolio model for competency assessment and self-regulated learning. The main components of ePortfolio models are shown in Figure 3.2.

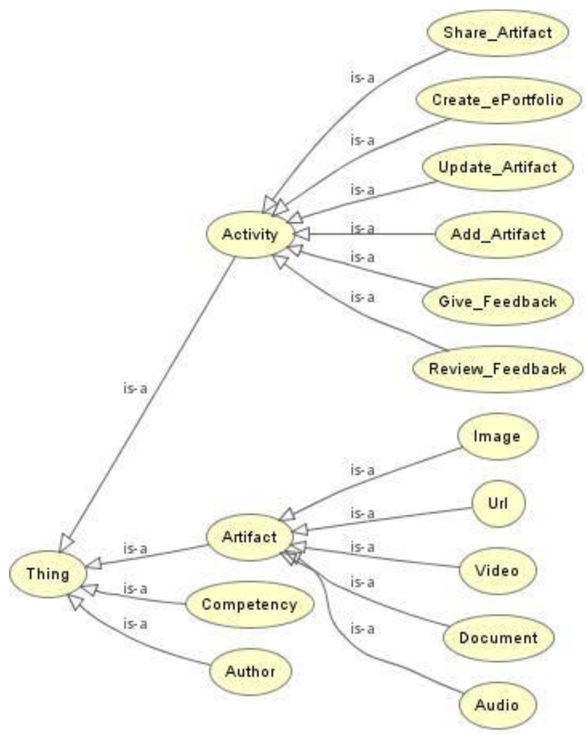



Figure 3.2 The components of ePortfolios.

### 3.2.2. Competency model

In this research, a particular `Competency` is known as `Knowledge` or a `Skill`, which is *required* for or *acquired* from learning `Activities`. Sicilia and Lytras (2005) argued that learning is made up of activities *performed* by a `Person` assuming a role; an activity may require some prerequisites and create some outcome competencies; and an activity may have some sub-activities. In addition, the similar competency models also were expressed by other researchers (Sicilia M.-A. , 2005; Macris, Papadimitriou, & Vassilacopoulos, 2008; Karetsos & Haralambopoulos, 2011; Schmidt & Kunzmann, 2006). According to these models, a learner performs a learning activity that has some required and outcome competencies in order to acquire new competencies. It is assumed that after finishing a learning activity learner acquire the outcome competencies.

A competency is specified by a domain, a proficiency level, and `Evaluation` entities (Karetsos & Haralambopoulos, 2011; Sicilia M.-A. , 2005). The concept of competency `Evidence` also proposed in (Schmidt & Kunzmann, 2006; Sicilia M.-A. , 2005). The components and relations of competency model are modeled in Figure 3.3.

We improved these ideas by emphasizing competency assessment and evidence in ePortfolio environments. We also implemented the assumptions in (Pfadenhauer, 2013; Gulikers & Mulder, 2013; Voorhees, 2001) by providing environments for multiple assessments that involve self and peer assessments, dialogue among stakeholders, and the performances.

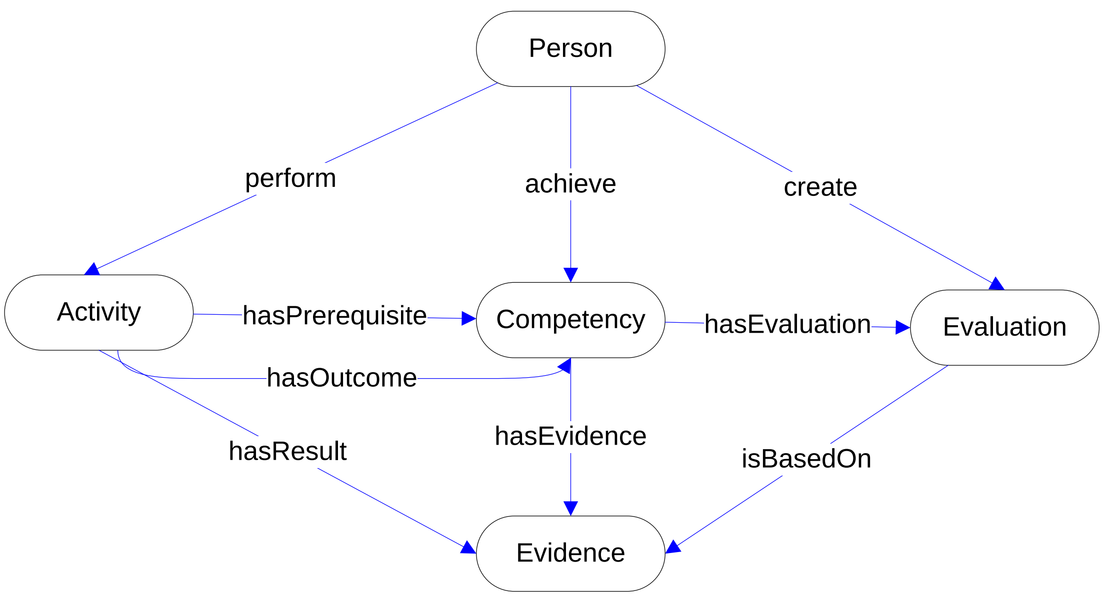



Figure 3.3 Competency model.

### 3.2.3. Self-regulated learning model

We can capture self-regulated learning models by using ontologies. For example, in (Shakya & Kumar, 2005; Siadaty, et al., 2008), the three phases self-regulated learning model (Zimmerman model) is represented. These ontological models represent self-regulated learning models in terms of processes. According to Shakya and Kumar (2005), to model SRL we model its tactics and strategies. A tactic is a specific learning process or activity, and strategy is a plan of learning contains a set of tactics.

Another well-known model is integrated model in (Pintrich, 2004), which includes four phases and four areas for regulation. The phases are forethought, planning, and activation; monitoring; control; reaction and reflection. The areas for regulation are cognition, motivation/affect, behavior, and context. The ontology for this model has two main components: `Phase_Activity` (processes) and `Regulation_Area` (domain). The `Phase_Activity` component involves sub activities of phases that *represent* the regulation of each domain in a phase.

For example, the three phase model and integrated model of self-regulated learning may be represented in ontology language as in Figure 3.4.

When we apply self-regulated learning for a specific domain, we have to combine `Self-regulated Learning Activity` with `Domain activity`. For example, use self-regulated learning to teach a programming language, we have to involve the strategies used for teaching this programming language, such as students have to write a simple demo for every new language e statement immediately after they have learnt. The combinations occur in all phases of self-regulated learning.

A way to combine self-regulated learning and domain is as follows: first, we create domain activity ontology and self-regulated learning activity ontology; second, we link the root of these ontologies to `Activity` component of the model. By this way, the ontology is flexible for including different domains.

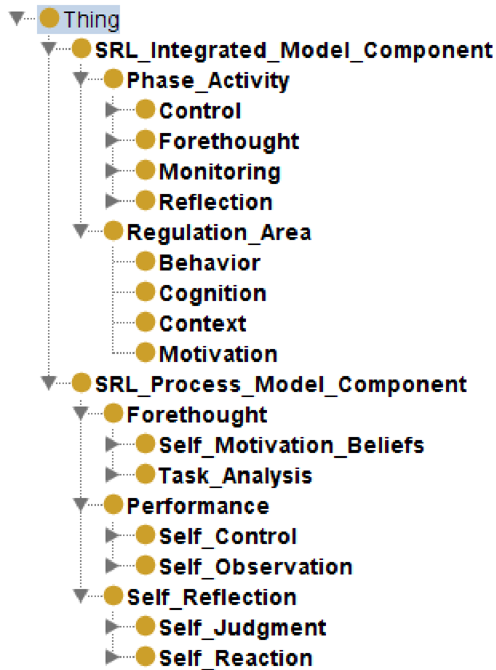



Figure 3.4 Self-regulated learning models.

### 3.2.4. Integrated model for foster self-regulated learning

Our approach to an integrated model for self-regulated learning is unifying common components of the sub models, which are self-regulated learning, competency, and ePortfolio models. The Table 3.1 shows the common components that are unified in an integrated model, and their corresponding roles in different models.

The integrated model has four components, which are the common components of the sub models. Persons are learners or teachers in self-regulated learning, competency owners or competency evaluators in competency model, and authors or readers in ePortfolio model. Activities are self-regulated learning tactics, domain strategies, ePortfolio activities, and activities that lead to achieving competencies or based on the achieved competencies. Artifacts are everything created and managed in ePortfolio system, which are created during learning activities and may be used as the evidence of competencies when assessing the competencies. Finally, competencies are knowledge and skills that are prerequisites or learning outcomes; competencies are represented and demonstrated by ePortfolios.

Table 3.1 An integrated model for fostering self-regulated learning.

| Components | Models | | |
|---|---|---|---|
| | ***Self-regulated learning*** | ***Competency*** | ***ePortfolio*** |
| Person | Learner, teacher | Owner, evaluator | Author, reader |
| Activity | Learning activities: self-regulated learning tactics and domain activities | Activities that create or use competencies | Activities performed on ePortfolio systems |
| Artifact | What learners create, refer when they learn | Evaluations or evidence | What users create and manage in ePortfolio system |
| Competency | Learning outcomes: knowledge and skills | Competency instance | What ePortfolio shows about knowledge and skills of a user |

### 3.3. Ontological ePortfolio model for self-regulated learning

Based on the conceptual model in Table 3.1, we proposed an ontology-based ePortfolio model to promote self-regulated learning. The target model is created from three sub models: ePortfolio, competency, and self-regulated learning. The challenge is how to combine them into a model that can promote self-regulated learning. We argued that using ontologies is a relevant approach. Indeed, with ontologies, we can create an integrated model by unifying common components of the ontological sub models, and specifying enhancive relations among the components of the models as analyzed in previous sections. For example, artifact in an ePortfolio model can be unified with evidence in a competency model; *has_evidence* is a relation between artifact and competency.

#### 3.3.1. Upper level ontology

The conceptual model shows that person, activity, artifact, and competency are four components of the model. These components are represented as the high-level classes of the ontological integrated model. In addition, we can view the combination in other perspectives, such as ePortfolios provide evidence of competency for assessment through artifacts and activities in ePortfolios, competency is the nature of an ePortfolio, or ePortfolios are environment, in which competencies are stored, demonstrated, and assessed.

Each component in Table 3.1 is represented by a class; and each relation between these components is specified by a property in ontologies. Figure 3.5 represents the upper level ontology of the model, in which the properties are represented by directional lines, and the labels of lines are property names. The lines drawn without a label represent *is-a* relations. In addition, Table 3.2 shows the summary of relation descriptions.

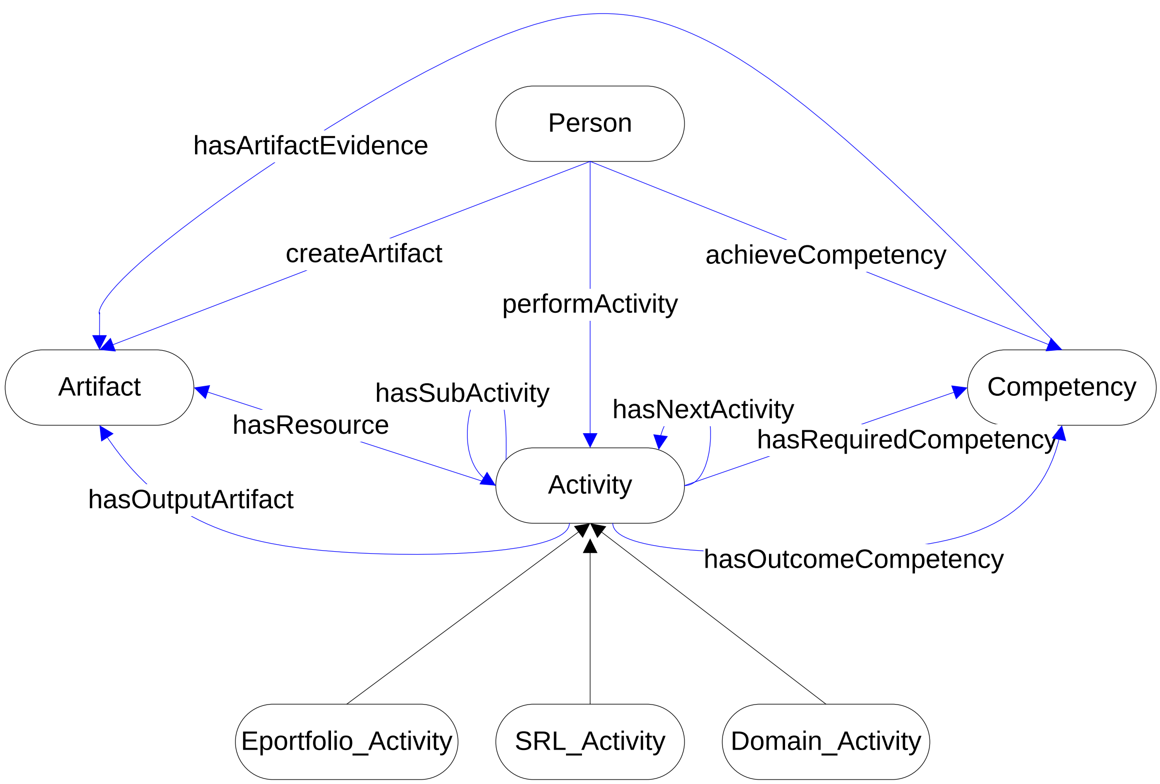



Figure 3.5 The upper level ontology of the ePortfolio model.

Table 3.2 Overview of properties in the upper ontology.

| **Property** | **Domain** | **Range** | **Description** |
|---|---|---|---|
| performActivity | Person | Activity | A person performs an activity |
| createArtifact | Person | Artifact | A person creates an artifact during learning |
| achieveCompetency | Person | Competency | A person achieves a competency |

| | | | |
|---|---|---|---|
| hasResource | Activity | Artifact | An activity has a resource that is used to carry out the activity |
| hasRequiredCompetency | Activity | Competency | A competency may be needed in order to perform an activity well |
| hasOutputArtifact | Activity | Artifact | An artifact may be created during doing a task |
| hasOutcomeCompetency | Activity | Competency | A competency may be a goal of activity |
| hasSubActivity | Activity | Activity | An activity may be a sub activity of another in the hierarchy |
| hasNextActivity | Activity | Activity | An activity may be the next/previous activity of another in a sequence |
| hasArtifactEvidence | Competency | Artifact | An artifact may be the evidence of a competency |
| Is_A | Eportfolio_Based_Activity<br>SRL_Activity<br>Domain_Activity | Activity | It is a sub-super class relation in a hierarchy. It means that ePortfolio activity is a kind of activity |

### 3.3.2. The ontology description and hierarchical structure

In the previous sections, we defined the four classes as disjoint with each other and the main relations among them. In this section, we describe more details of the ontology.

In self-regulated learning model, a person may be a learner or a teacher. In competency model, there are two main roles of people: as owner of a competency and evaluators who assess the competencies of others. Author and reader are two main roles of people in ePortfolio. The terms learner, teacher, owner, evaluator, author, and reader do not describe categories of humans, but are roles that human can play. Therefore, it is necessary to add `Role` as a class in the ontology. We use *hasRole* to specify a person play some roles in the model: `Person` *hasRole* `Role`. Thus, 'learner', 'teacher', 'owner', 'evaluator', 'author', and 'reader' may be represented as instances/individuals or as subclasses of `Role`. Meanwhile, a `Student` is defined as a person who has 'learner' role and an `Instructor` is a person whose role is 'teacher'.

Activity is a critical and central concept in the proposed model, where we integrated SRL_Activity, Domain_Activity, and ePortfolio_Activity into one concept. By this way, the self-regulated learning models are embedded in ePortfolio platform. Thus, the activity in the model involves learning activities (self-regulated learning tactics and domain activities) and ePortfolio activities. An activity is performed by a person (Person *performActivity* Activity), and is evaluated by some people, such as the author, instructors, and peers. Evaluators specify their judgments in evaluation instances (Activity_Evaluation); each of evaluation instances has progress information (Activity_Evaluation *hasEvaluationProgress* byte) and feedback about the activity (Activity_Evaluation *hasFeedback* string). The evaluations of an activity are unified into a unique progress of the activity (Activity *hasProgress* float).

An ePortfolio Artifact is a unit of digital resource that can be used to support learning (Wang S. , 2009). In this research, an artifact is everything created and managed in ePortfolio systems during teaching and learning processes. Artifacts include following components: Program that is a course, an academic program, or an activity; Plan that involves Program_Plan and Student_Plan; Resource for a program or an activity, which was suggested by instructors or students; Output_File is a document created from an activity; Comment is feedback from an instructor or a peer about activities or competencies of students; and two kinds of evaluation, Activity_Evaluation and Competency_Evaluation. Artifacts are used for instruction design, teaching, learning, and especially, for evaluating students' competencies. Artifacts provide assessment information via evaluation instances and competency evidence for competency assessment.

A Competency is Knowledge or a Skill, which is required for or achieved through learning activities. In this research, competencies are specified as visible and explicit elements of ePortfolios. These elements are representations of knowledge and skills achieved by students or the goals to be achieved. Competencies are evaluated through Competency_Evaluation instances, which are split into two kinds of evaluation: Self_Competency_Evaluations and External_Competency_Evaluation. Each evaluation contains a level represented in byte (Competency_Evaluation *hasEvaluationLevel* byte) base on the evidence and judgment of an evaluator. The levels of evaluation instances of a competency are unified into a unique level that attach to the instance of competency to represent the proficiency level of an achieved competency (`Competency` *hasLevel* `float`).

We proposed two kinds of evidence: artifact evidence and process evidence. An artifact may show the evidence of a competency via its contents or its creation process, this relation is represented by two properties (`Competency` *hasArtifactEvidence* `Artifact` or its inverse `Artifact` *isArtifactEvidenceOf* `Competency`). An artifact can be evidence for a competency if it is created from an activity that related to the competency, for example, the competency is a goal of the activity. Intuitively, it is assumed that a learner has knowledge and skills before they can use the knowledge and skills to create artifacts, which demonstrate the learner's competencies. However, from evaluator perspectives, we need evidence before making conclusions about the competencies of a person. For example, we have artifact (*A*), and competency (*C*). The first perspective: *C creates A*, and the fact that there is *A*, thus *C* may be true (via abduction). The evaluators' perspective: if *A then C*, and there is *A*, so *C* is true (via deduction). Therefore, in both perspectives, it is reasonable to use artifacts as evidence of competencies.

In addition, the other kind of evidence is the process of achieving competency or using achieved competency (Pfadenhauer, 2013; Gulikers & Mulder, 2013; Voorhees, 2001). The processes are created from activities that started and evaluated. The activities are connected to each other by relations, such as *hasSubActivity, hasSuperActivity, hasNextActivity, hasPreviousActivity.* Thus, we can create a sequence of activities to explain how a competency is achieved or to demonstrate how a competency is used by using these relationships.

We propose two statuses of competencies, which are 'goal' and 'achieved'; also, there are two statuses of activities: 'plan' and 'started'. When evaluating achieved competency started activities are used. In other words, only started activities can be evidence for achieved competency. An activity can be considered as evidence of a competency based on their relations with the competency, for example, *hasOutcomeCompetency* and *hasRequiredCompetency*. By using the former, we assume that if a learner completes an activity he/she will acquire the outcome competencies of this activity (this show how learner acquire new competencies). On the other aspect, the latter assumes that a learner must achieve required competencies before he/she can complete an activity (this show how the learner use achieved competencies).

An `Instructor` also relates with other concepts, for example, instructors create programs (`Instructor` *createProgram* `Program`), instructors create program plans (`Instructor` *createProgramPlan* `Program`), instructors create activity evaluations (`Instructor` *createActivityEvaluation* `Activity_Evaluation`), and instructors create competency evaluation (`Instructor` *createCompetencyEvaluation* `Competency_Evaluation`). Students can create their personal plans (`Student` *createStudentPlan* `Student_Plan`), artifacts (`Student` *createArtifact* `Artifact`), activity self-evaluations (`Student` *createSelfActivityEvaluation* `Self_Activity_Evaluation`), and competency self-evaluation (`Student` *createSelfCompetencyEvaluation* `Self_Competency_Evaluation`).

In summary, based on the analysis and explanations above, we can describe the ontology as follows: A Person is Student or Instructor. Learners perform learning activities that have some required competencies and some outcome competencies in order to achieve some competencies. An activity in ePortfolio perspective is an action carried out by using ePortfolio systems, such as learners use ePortfolios to create learning plans, or learning activities that occurs outside ePortfolios but their information is traced in ePortfolio systems. An activity may be a started activity or a planned activity, and it has some resources and outcome artifacts. A competency is knowledge or skill that has a domain, a proficiency level, and some competency evaluation entities. A competency may be an achieved competency or a goal competency. A competency may be evaluated by some evaluators. When a person evaluates a competency, a competency evaluation instance is created, which contains a level of competency and feedback. If a competency is evaluated by owner, the competency evaluation is self competency evaluation; if the evaluator is a peer or a teacher, the competency evaluation is external competency evaluation. An instance of a competency contains a domain and the unified level of all evaluation instances' levels in some ways, for example, using the minimum level, or average level for the unified level. Artifact is everything people created and stored in ePortfolio system through activities. For example, learning plans, files created through learning activities, feedback, responses, and evaluations. An artifact may be a resource for learning activities, an outcome of activities, or an evidence of learner's competencies.

From the components and the main relations were described above, the class hierarchy structure of the ontology is represented in Protégé tool as in Figure 3.6. This structure shows the subclasses of the main classes in the ontology. In addition, the other properties were listed in Table 3.3.

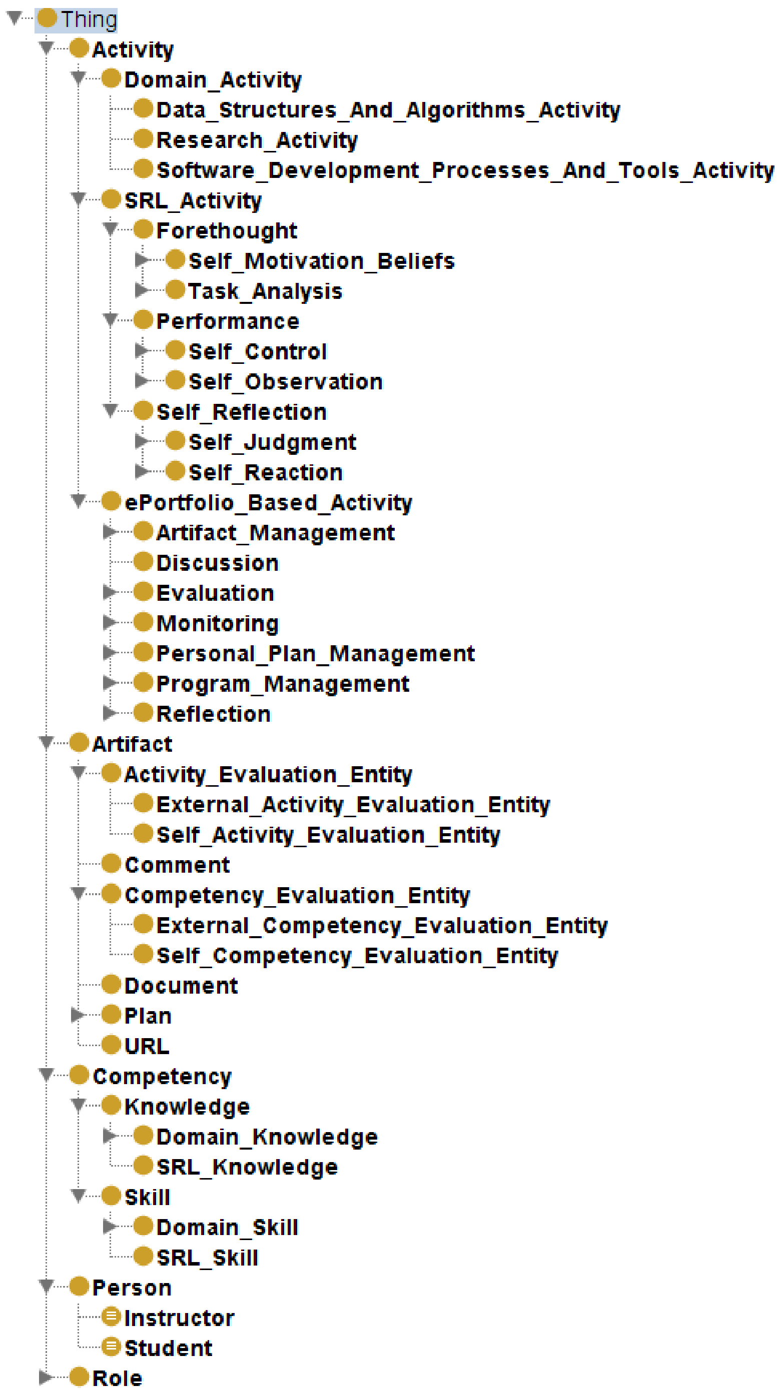



Figure 3.6 The hierarchical structure of the classes.

Table 3.3 Other properties in the ontology.

| Property | Domain | Range |
|---|---|---|
| hasRole | Person | Role |
| createActivityEvaluation | Person | Activity_Evaluation_Entity |
| createArtifact | Person | Artifact |
| createCompetencyEvaluation | Person | Competency_Evaluation_Entity |
| createProgram | Instructor | Program |
| createProgramPlan | Instructor | Program_Plan |
| createSelfActivityEvaluation | Student | Self_Activity_Evaluation_Entity |
| createSelfCompetencyEvaluation | Student | Self_Competency_Evaluation_Entity |
| createStudentPlan | Student | Student_Plan |
| hasActivityEvaluation | Activity | Activity_Evaluation_Entity |
| hasActivityEvaluator | Activity_Evaluation_Entity | Person |
| hasCompetencyEvaluation | Competency | Competency_Evaluation_Entity |
| hasCompetencyEvaluator | Competency_Evaluation_Entity | Person |
| hasSelfActivityEvaluation | Activity | Self_Activity_Evaluation_Entity |
| hasSelfCompetencyEvaluation | Competency | Self_Competency_Evaluation_Entity |
| joinProgram | Student | Program |
| hasEvaluationLevel | Competency_Evaluation_Entity | byte |
| hasFeedback | Competency_Evaluation_Entity<br>Activity_Evaluation_Entity | string |
| hasEvaluationProgress | Activity_Evaluation_Entity | bype |
| hasEvaluationTime | Competency_Evaluation_Entity<br>Activity_Evaluation_Entity | dateTime |
| hasProgress | Activity | float |
| hasLevel | Competency | float |
| isAchieved | Competency | boolean |

### 3.3.3. How can the proposed model promote self-regulated learning?

The proposed ontological model may promote self-regulated learning in some aspects: 1) to capture and share self-regulated learning principles, to provide common vocabulary for knowledge representation, building programs, plans, and learning strategies; 2) to be a guide to build learning support system, which fosters self-regulated learning, develop teaching and learning models, in which teachers and students use ePortfolio platforms to improve evaluation and reflection skills in order to approach self-regulated learning; 3) to be a meta-model for ePortfolio systems implementations, and is used to create the knowledge bases of the ePortfolio systems, and then the knowledge bases are combined with semantic web tools in order to provide an interactive learning environment for learners, which can improve communication, support user in evaluating competency and performance, sharing resources, and seeking help.

An ontology is a strong tool for representation and sharing knowledge (Gruber, 1993; 1995). In order to promote self-regulated learning we need to represent the self-regulated learning principles in a formal way and try to disseminate these principles to receivers (Shakya & Kumar, 2005). Indeed, understanding about self-regulated learning is the first and the most important factor that makes a learner or a teacher can learn or teach in a self-regulated learning way or not (Zimmerman, 1998). The elements relate to self-regulated learning, such as teaching and learning strategies and learning outcomes need to be specified in a formal form in order to improve the efficiency of understanding and sharing.

The ontologies are built to capture the knowledge about a model that promote self-regulated learning by using ePortfolios and model learner competency assessment in ePortfolio environment. They are used as explicit documents of knowledge about the proposed model to represent and share knowledge about the model. The ontological model captures and shares self-regulated learning principles. The knowledge from the model may help stakeholders understand and obtain more knowledge about learning methods.

An ontology also is used as a common vocabulary about ePortfolio, competency, and self-regulated learning among people and systems. The ontology becomes a common vocabulary for building programs and plans and evaluating competencies. For example, in an ePortfolio system implemented from the model, an ontology may become a shared vocabulary among the users in order to share knowledge about programs, learning strategies. Indeed, program designers can use the same ontology to design programs, the ontology provides terms about activities, learning outcomes, resources, etc. When learners build their plans they can browse the ontology and select activities to add to their plan, the activities include self-regulated learning tactics and domain activities. By this way, self-regulated learning principles, which were captured in the ontology, are transferred to and used by other people.

From the system development perspectives, an ontology may become guidelines for designing and training. The proposed ontologies are used for guiding system design, system training, knowledge base building, or providing semantic reasoning based features of learning support systems. The ontological model is useful for designers, teachers, learners, and researchers, especially, in the fields of competency measuring, self-regulated learning, and educational system.

The use of ontology and semantic web technologies provides reasoning ability for supporting learning through semantic matching ability. An example of the use of ontology-based inferring is learning resource recommendation. For example, a student know a book (*b*), which is suitable for a type of learning activity (*A*), and then he/she set this book as a resource for that kind of learning activity. The information is captured in an ontology by an assertion of ObjectProperty *hasResource,* which represents a relation between Activity and Artifact in an ePortfolio system. In the future, if other students add an instance of activity *A* into their plan, then the system will recommend the book *b* as a suggested resource for them based on reasoning.

Another kind of reasoning is using rules. Ontologies allow us to represent constraints by a set of rules. For example, we have a simple rule, such as if a student responds a feedback then he/she does reflection. By using this kind of knowledge, we can evaluate how students follow self-regulated learning in their learning. The above example of rule represents a relationship between an ePortfolio activity and a self-regulated learning activity. In this case, responding a feedback is an ePortfolio activity, which was logged automatically by the system, after we apply reasoning by using the rule, a self-regulated learning activity – reflection – is generated.

### 3.3.4. The proposed model and knowledge sharing

Knowledge sharing includes processes in which the knowledge is transferred from a source to a recipient (Cummings, 2003). The success of knowledge sharing is measured in term of how much the knowledge is internalized in the recipient. Thus, the factors that affect knowledge internalization process are considered as the factors that promote or inhibit knowledge sharing. From this aspect, knowledge sharing can be viewed as a learning process through which learners receive the sharing information from teachers and then create their own knowledge. In order to foster knowledge internalization, researchers suggest that an organization needs to adopt an active learning perspective through which it fosters the recipient improve its learning experiences, can actively receive, adapt, or reconfigure the knowledge to its needs.

There are some factors that affect knowledge sharing, such as source knowledge, motivation, transmission channels, learning ability (Gupta & Govindarajan, 2000); people, processes, and IT systems (Kaps, 2011); type of knowledge, cognitive style, and nature of transacting patterns (Bhagat, Kedia, Harveston, & Triandis, 2002); socialization of team members and information technology (Lagerstrom & Andersson, 2003). In sumary, not only knowledge representation but also environment and cognitive skills affect knowledge sharing.

In addition, learning plays a significant role in knowledge sharing process because learning ability affects the level of internalization or absorptive capacity of the recipient. Indeed, knowledge and learning are considered as an integrated whole (Lytras & Sicilia, 2005). Yoon, Song, and Lim (2009) pointed out major factors for knowledge creation to occur, such as members' continuous learning, interactive collaborations, reflective dialogue through the teams, supportive learning culture, and collaborative communications. Successful knowledge sharing requires an ongoing process of learning interactions, rather than just a series of communications (Szulanski, 2000).

From the above points of view, it is argued that the proposed model may affect knowledge sharing. Indeed, the model is a combination of ontology, ePortfolios, and self-regulated learning. We can map these components to the major categories of factors that affect knowledge sharing. Ontologies are used to represent knowledge in a way that is easy to understand and share. Self-regulated learning skills are necessary for improving cognitive skills and learning skills. Finally, ePortfolio platform is a consistent environment in which knowledge and cognitive skills are embedded and implemented. ePortfolio platform is also a relevant environment for knowledge sharing, especially, sharing knowledge about learning strategies and human competencies. The relations between proposed model's components and knowledge sharing are described in a conceptual model in Figure 3.7.

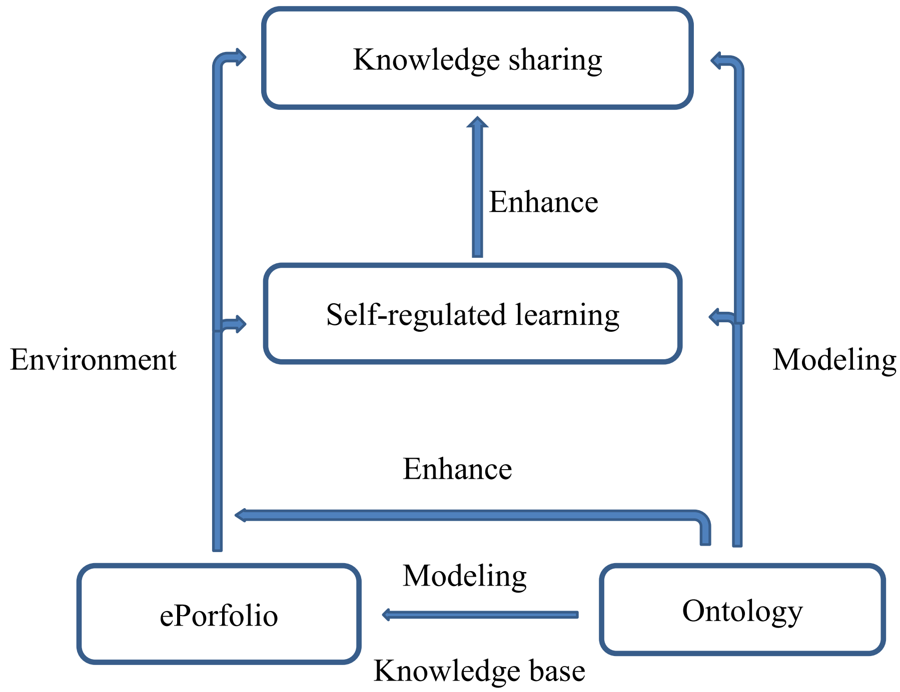



Figure 3.7 A conceptual model for fostering knowledge sharing.

## 3.4. The ePortfolio system design based on the ontological model of self-regulated learning

### 3.4.1. The use of the proposed model in system development

First, we used the model as a medium for communications about the system during the development phases, especially, in specification, design, and training phases.

Second, the model was a meta-model for system development. Indeed, the model's components were used to design and develop the components of the system. For example, person, activity, artifact, and competency are main elements in the ePortfolio system, while the relations in the model and the content of Activity component were used as guidelines for providing the main functions of the system. In addition, the ontologies play an important role in database design.

Third, the model was used to create the knowledge base of the system in order to provide learners with more features based on semantic reasoning, such as supports in resource selections, help seeking. In addition, the knowledge base (ontologies) improves ability to share/transfer knowledge, such as self-regulated learning and domain strategies, among people and systems. The ontologies also improve the ability to understand learning theories of the ePortfolio system.

Finally, the model was a guideline for ePortfolio-based learning model design. This learning model uses the ePortfolio system as learning environment in which we can implement and evaluate self-regulated learning skills in a particular domain in order to foster student self-regulated learning.

### 3.4.2. The ePortfolio system architecture

We developed an ePortfolio system as a web application. Figure 3.8 shows the components of the system. Graphical User Interface is a set of web forms designed by using jQuery and ASP.NET technologies. The controller contains ePortfolio business processes, which were implemented in C# language. Database is built in MS SQL Server DBMS. Knowledge Engine involves algorithms and free reasoners and APIs for ontology processing. Ontology module is a set of ontologies built in OWL language, which works as a knowledge base of the system and contains the model, the instances, and asserted relations.

The data is stored in both modules: database and ontology. The database contains the full information of all objects, while the ontology contains the main information of main objects that is necessary for sharing knowledge and semantic reasoning. For example, the full information of an artifact, such as id, name, description, and the file of the artifact are saved in database, while the system just assert the id of the artifact into ontology for reasoning purpose. However, the system allows linking the id in ontology to the full information in database.

The main actors of the ePortfolio system are learners and instructors. However, other actors also use or affect the system, such as knowledge engineer who can modify the ontology module directly and the readers who want to have information about learners via the system.

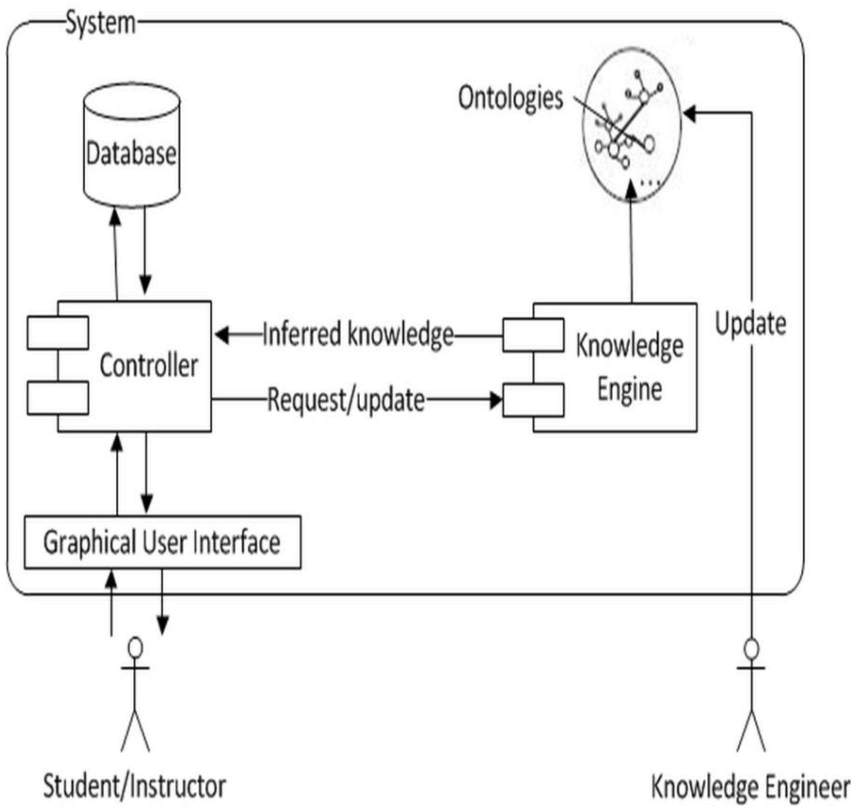



Figure 3.8 The ePortfolio system architecture.

### 3.4.3. The main functions of the system

The goal of the system design is to foster self-regulated learning. The system was designed in order to help the users overcome the issues of self-regulated learning, such as practicing, measuring, and modeling self-regulated learning skills. Based on the self-regulated learning strategies and models, the system has the following functions.

For instructors, they can use the system to design a program (a program can be an academic program or a course) that consists of activities and learning outcomes. For each activity instructors can specify its prerequisite and goal competencies. Next, instructors create program plans with stages, activities and resources for learning. Finally, the instructor can observe, evaluate students' activities and learning outcomes, and discuss with students.

Students can use the system to create their learning plans based on program plans, goal competencies, suggested resources, and their contexts. They can manage and share artifacts through the system. Students also can monitor and evaluate their task progresses, learning outcomes, they also can review and reflect on feedback and results.

The ontology module is an important component. The system uses this component as a knowledge base to provide learners with the advanced features, for example, sharing knowledge, and suggesting resources. Users can browse, update, and share ontologies via the interface of the system. We can specify the relationships among components, such as activity, competency, artifact, and person. The system can insert individuals and assert relationships into ontology automatically.

The ePortfolio system is a platform for interaction between students, students and lecturers. This tool promotes self-studying, reflecting, and motivation. In addition, the system can log learning activities and provide log analyzer for evaluation purposes.

### 3.4.4. How can the ePortfolio system promote self-regulated learning? - An example from a process based self-regulated learning model.

Bartolomé and Steffens (2011) indicated three characteristics, which a technology enhanced learning environment should meet in order to be capable of supporting self-regulated learning, which are abilities to encourage learners to plan their learning activities, allow learners to receive feedback and monitor their learning, and support learners to evaluate their own learning. In addition, Zimmerman & Tsikalas (2005) claimed that computer-based learning environment that support self-regulatory processes in all three phases are more likely to produce positive, self-sustaining cycles of learning. They also argued that computer-based learning environment should explicitly address motivational aspects of self-regulated learning in order to encourage students to assume responsibility for and take charge of these processes.

Indeed, the ePortfolio based learning model leads learners to follow self-regulated learning activities and log these activities for assessing and supporting purposes. All processes are captured; therefore, the system may improve evaluating and supporting. We have three categories of activity: ePortfolio activity, self-regulated learning activity, and domain activity. ePortfolio activity is a class of actions that the user can do by using ePortfolio, this kind of action can be logged automatically when the user use an ePortfolio system. Self-regulated learning activity is class of activities that make up self-regulated learning model. Domain activity is class of activities which make up teaching and learning strategies for a specific domain. It is what students should do when they learn a domain. Learners may perform learning activity (self-regulated learning and domain activity) outside ePortfolio systems, for example, doing assignments. Thus, self-regulated learning activity and domain activity may not be logged automatically; instead, they are captured via ePortfolio activity and rule-based reasoning. For instance, if a student uses an ePortfolio system to create a plan it means that the student performs an ePortfolio activity called *create_student_plan,* which is logged automatically. Thus, we can conclude that the student has performed *planning* in self-regulated learning process. For example, in an ontology we can specify ePortfolio activity *create_student_plan* is a subclass of *planning* in self-regulated learning sub ontologoly. We also can declare these two activities are equivalent. A domain activity is captured in an ePortfolio system when a student adds it into his/her personal plan, and will be updated its status by other ePortfolio activities, such as evaluating progress, evaluating outcome competencies, setting outcome artifact of an activity, or based on the duration of the activity, which is determined by start and finish time.

In addition, from the data about activities ePortfolio systems may notify or provide recommendations about what learners should do next in order to follow the self-regulated learning processes or a plan. For example, after registering a program, students have to create their personal plans for the program. If students do not create plans before using other activities, such as artifact management, the system will know and notify students about the issue.

The following explains how can the ePortfolio system support self-regulated learning in terms of sub processes in three phases model of Zimmerman (2002).

#### 3.4.4.1. Forethought

This phase has two major classes of processes: task analysis and self-motivation. Task analysis includes goal setting and strategic planning. In order to support goal setting, the ePortfolio system provides program concept, which can be a course, an academic program, or an activity. A program is created by instructors and contains some learning activities with their required/outcome competencies. When joining a program, students can observe the program to know its learning outcomes in terms of outcome competencies of each activity, and then determine which competencies will be included in learning goals.

Along with the program, instructors create program plans by selecting activities from the program or adding new activities. Activities in a program plan have required/outcome competencies and resources for each activity. Program plans provide information for students when they create personal plans. In order to improve autonomy and flexibility, the system allows students to create personal plans, which are different from program plans based on learning goals and current state of students. To create a personal plan, a student has to determine goal competencies, and then select the corresponding activities.

Self-motivation beliefs come from students' beliefs about learning. The ePortfolio system helps students know the prerequisites of learning activities, track, and observe their performances. It leads to increase in self-satisfaction, and then in self-motivation. In addition, what a student achieved can be stored, showed to, and evaluated by instructors and others; it means others recognize his/her achievements; this may lead to increase in students' motivation. In addition, the resources and feedback from instructors and peers via the ePortfolio system may become the sources of motivation.

#### 3.4.4.2. Performance

This phase includes self-control and self-observation. Self-control refers to implementing the strategies, which were determined in the planning stage. By creating personal plans, students have a chance to think about the methods and strategies, which can help students to learn well, before adding relevant activities into plans to form learning strategies. Personal plans record strategies and work as a gateway, where student can start and observe learning activities. Thus, learning plans increase focus and enhance attention. In addition, the task strategies of domains are shared by instructors and students through program plans, resources, and shared artifacts. These task strategies may be reused and represented in personal plans, which are used as guidelines during learning in order to help students control themselves and reach to goals.

The ePortfolio system records personal activities by logging operations, which relate with activities, such as adding an activity to a plan, setting outcome artifacts of an activity, and evaluating progress of an activity. In addition, the ePortfolio system contains and shows activities in plan, the results of the activities via artifacts, progress, and competency evaluations.

Thus, these recordings help students to observe themselves more effectively, and finally, monitor their cognition.

#### 3.4.4.3. Self-reflection

This phase has two processes: self-judgment and self-reaction. By tracking processes, storing and showing the results of the processes, the ePortfolio system supports students a lot in self-assessment. Indeed, the ePortfolio system provides necessary information for students in order to support them in understanding about what they have done and created, and consequently they may have better evaluations about their achievements. In addition, the information from ePortfolios can help students to analyze causal attributions. Students may attribute poor results to controllable processes, for example, the use of irrelevant strategies; finally, they may change the strategies in order to have better results.

In order to promote self-reaction, the ePortfolio system provides students with a relevant environment, in which students can receive feedback from instructors and peers through discussions and evaluations. Students can react by discussions, updating self-assessments, changing personal plans, reviewing and changing artifacts. In addition, other forms of self-reaction are self-satisfaction and defensive response. As mention above, the ePortfolio system can enhance self-satisfaction because of achievement recognition. Students also can decide who can see what information through ePortfolios in order to protect one's self-image.

## 3.5. ePortfolio-based self-regulated learning

Based on the above analyses and self-regulated learning models, an ePortfolio system has been 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). There was a focus on academic courses. 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 as a platform for interactions between students and instructor and among students. It fosters self-study, self-reflection, and motivation.

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) by using the form in Figure 3.9. Program activities and competencies are added in hierarchy structures as in Figure 3.9 (a) and (b). Next, for each activity, its prerequisite competencies and outcome competencies (specified in Figure 3.9 (c) and (d)). Instructors select an activity in part (a) and drag competencies in part (b) into part (c) or part (d). 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 they can be shared or reused among instructors.

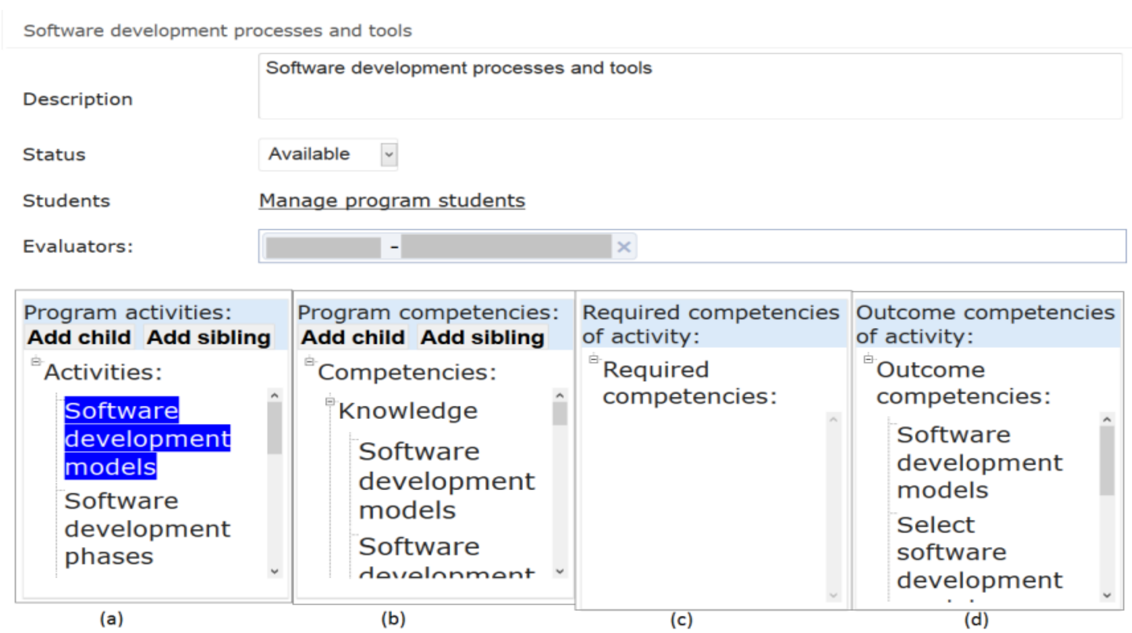



Figure 3.9 The Program Form.

Students that 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 condition. Figure 3.10 illustrates a personal plan for a course. 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. For example, Figure 3.11 shows the elements of ‘SD process improvement’ activity (in Figure 3.10). In plan forms, students also can participate in program discussion with all students and instructors of the course.

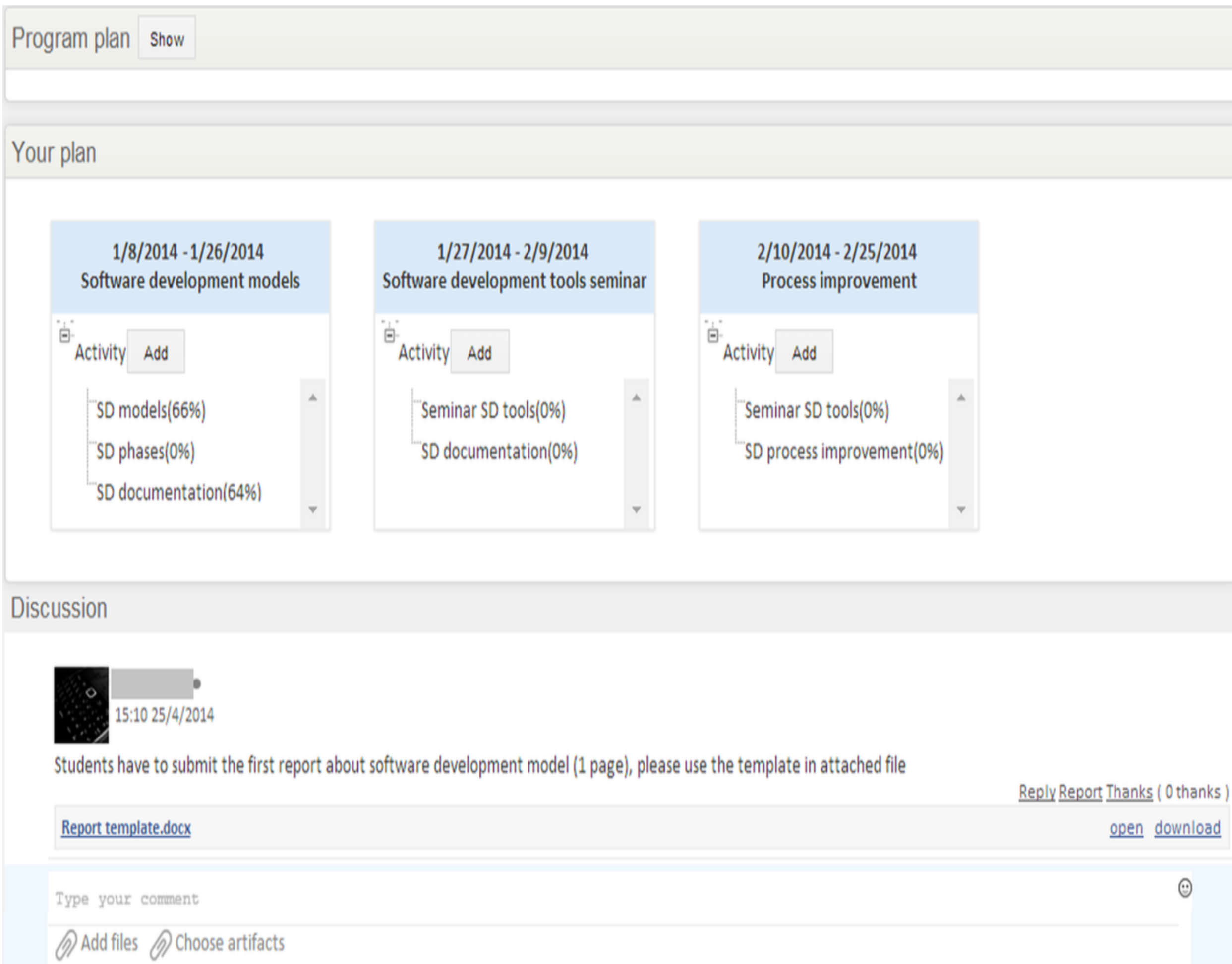



Figure 3.10 The Personal Plan and Program Discussion Form.

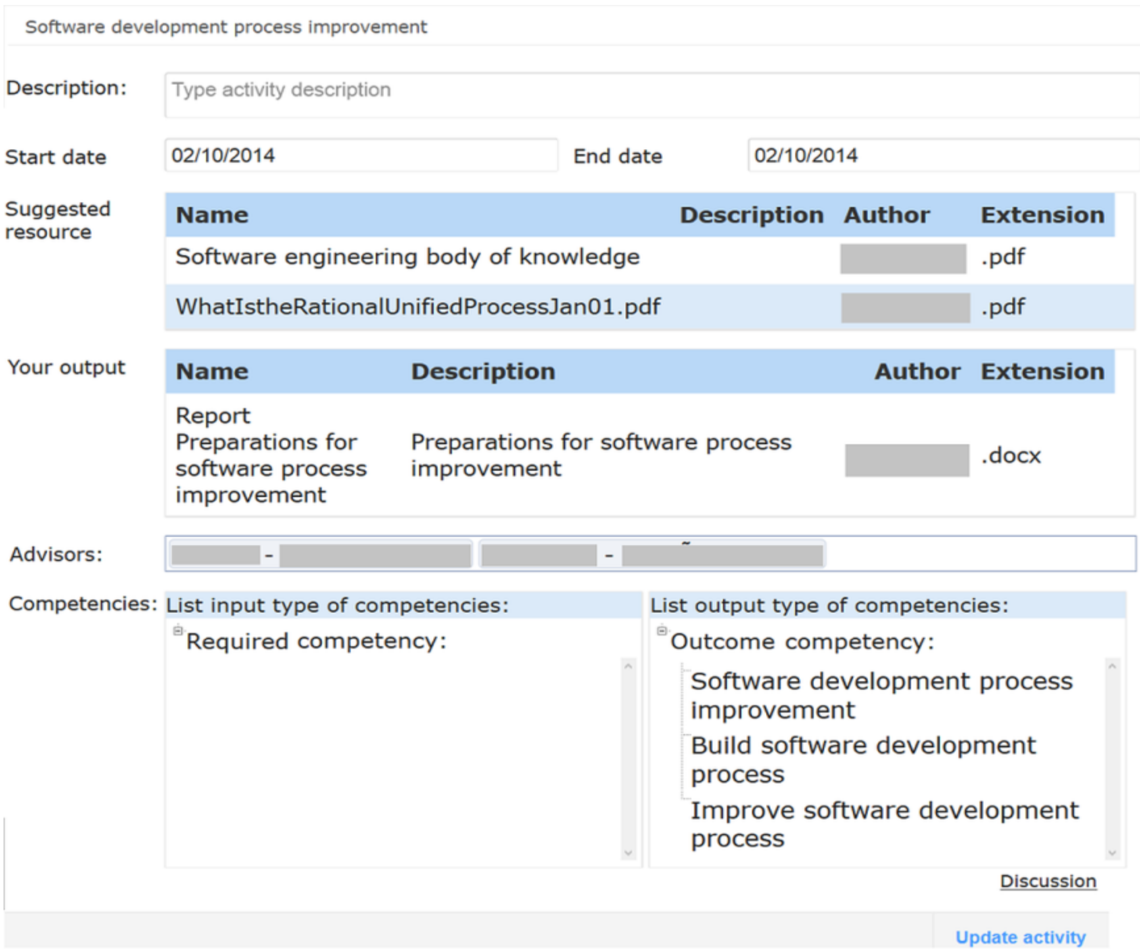



Figure 3.11 The Activity Information Form.

To add a new artifact or modify an existing artifact users use the form in Figure 3.12. From this form learners may set artifact evidence for competencies by selecting the activity that creates the artifact, the activity come from the personal plan and is set in 'Output of Activity' field. Learners and instructors also can share an artifact or set it as a resource for a kind of activity by using this form and selecting type of activity from 'Use for Type of Activity' field. This field is linked to the ontology (the ontology is showed as in Figure 3.13); this means that users select activities from the ontology and the setting is asserted into the ontology. If other users use the selected type of activity for their plan, they can see the resources that attached to this activity type. That is why the information may be shared.

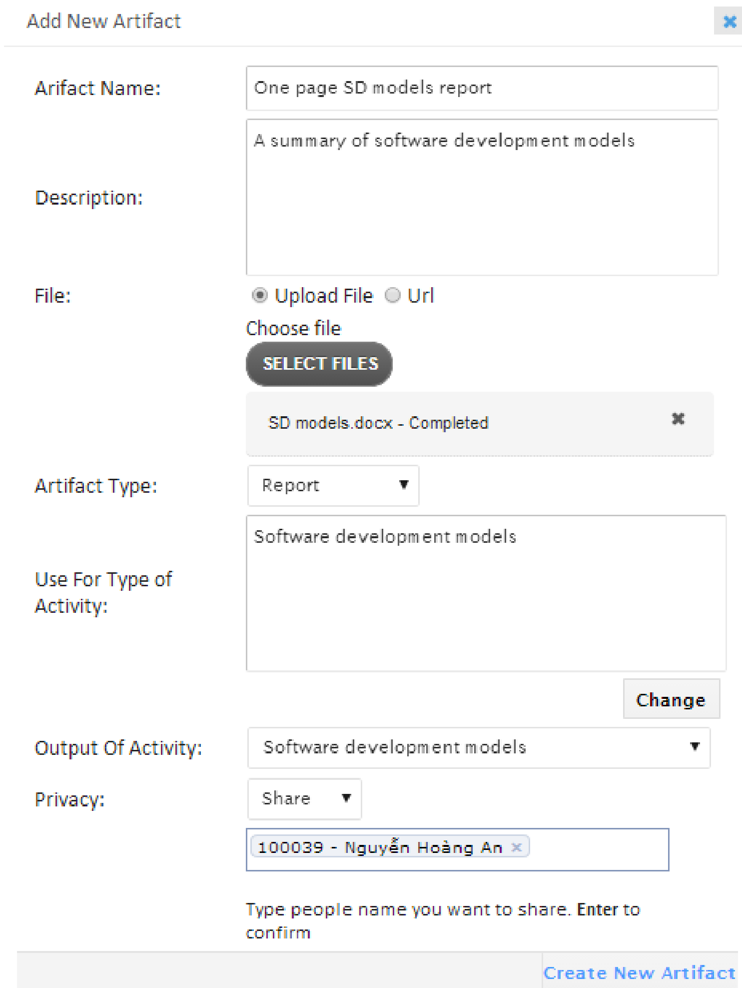



Figure 3.12 The Edit Artifact Form

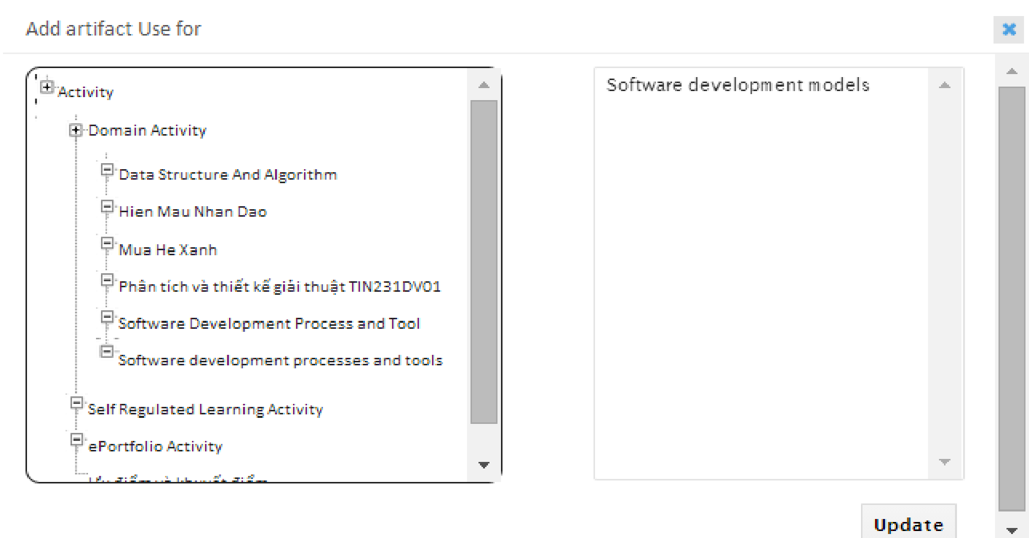


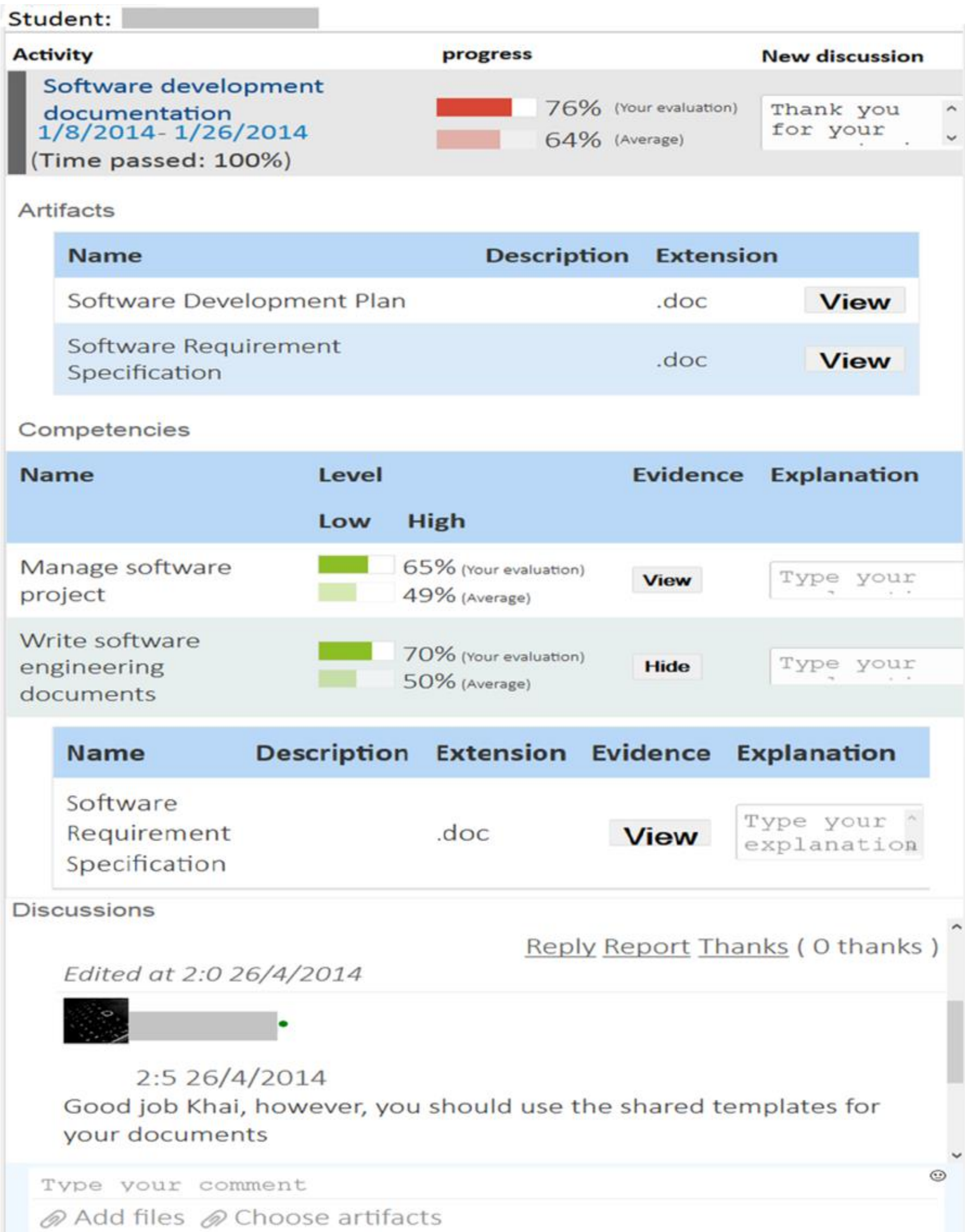

Figure 3. 13 The Activity Component of The ontology showed in GUI

During the courses, students use the ePortfolio system to observe learning, refer to resources and learning outcomes, manage artifacts, evaluate activities and competencies, review feedback, update plans, and discuss learning with peers, tutors, or instructors. Instructors and tutors can review students' plans, monitor performances, check output artifacts or competency evidence, evaluate activities and competencies, and give feedback to students through the ePortfolio system.

Figure 3.14 is an evaluation form for an activity that 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. This part shows two kinds of progress: self-assessment progress and average progress of all evaluations 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 two kinds of competency level also displayed in this part in order to improve learners' awareness of self-assessment. The last part contains the discussions that are related to the type of the selected activity. Participants also can thank other person for a valuable post or attach files to share with the others.

The evaluation form was designed in order to support the users in evaluating activity and competency, linking activity, competency, and artifact, improving learners' awareness of self-assessment, mornitoring learning, and enhancing metacognitive skills.

By using this form, the learners may improve the motivation and strategies of learning. Consequently, the self-regulated learning skills will be improved. For example, this form help the learners show their learning results to the others, and they can communicate with others about these results. It means that the form improves the recognition of learning results; this improvement leads to higher motivation in learning. Another example, this form also provides learners a tool for practicing critical thinking skill by reviewing activity and competency, monitoring progress, reflecting on progess, discussing and analyzing. This form also keeps learners' critical thinking artifacts that may be helpful to them during learning.



Student:

| Activity | progress | New discussion |
|---|---|---|
| Software development documentation 1/8/2014- 1/26/2014 (Time passed: 100%) | 76% (Your evaluation) 64% (Average) | Thank you for your |

Artifacts

| Name | Description | Extension | |
|---|---|---|---|
| Software Development Plan | | .doc | View |
| Software Requirement Specification | | .doc | View |

Competencies

| Name | Level (Low / High) | Evidence | Explanation |
|---|---|---|---|
| Manage software project | 65% (Your evaluation) 49% (Average) | View | Type your |
| Write software engineering documents | 70% (Your evaluation) 50% (Average) | Hide | Type your |

| Name | Description | Extension | Evidence | Explanation |
|---|---|---|---|---|
| Software Requirement Specification | | .doc | View | Type your explanation |

Discussions

Reply Report Thanks ( 0 thanks )

*Edited at 2:0 26/4/2014*

2:5 26/4/2014

Good job Khai, however, you should use the shared templates for your documents

Type your comment

Add files Choose artifacts

Figure 3.14 The Activity Evaluation and Discussion Form.

### 3.6. Experiment and Evaluation

In order to evaluate the system and test how the ePortfolio system affects students' self-regulated learning, we conducted the first experiments at the Hoa Sen University, Vietnam. The ePortfolio-based self-regulated learning model was used in two courses: Data Structure and Algorithms (DSA), and Software Development Processes and Tools (SDPT). The DSA class had 44 students (39 male students and 5 female students, 13 fourth year and 31 third 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, 18 students (15 male students and 3 female students, in which, 12 fourth year and 6 third year students) were recommended to use the ePortfolio system for this course. The students used the ePortfolio system for learning for eight weeks. The courses were taught by the lecturers of Hoa Sen University.

#### 3.6.1. System evaluation

For system evaluation, we developed a questionnaire based on Post Study System Usability Questionnaire (PSSUQ) (Lewis, 2002) and additional items related self-regulated learning. The questionnaire consists of 5 scales (overall, system usefulness, information quality, interface quality, and effectiveness), and 22 questions, which the students rated using a Likert scale from "1 strongly disagree" to "7 strongly agree". We also collected data of grades and used unpaired 2-tailed t-test with p-values of $<0.05$ were considered significant to evaluate the effects of the ePortfolio system on students' achievement.

#### 3.6.2. The effects of the ePortfolio system on self-regulated learning

In order to test how the ePortfolio system affects students' self-regulated learning, we used both self-report and trace methods.

##### 3.6.2.1. Self-report

To measure self-regulated learning, a self-reporting method with the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, & McKeachie, 1991) was used. MSLQ allows us to measure different motivational components and the use of learning strategies in a given course. In addition, Pintrich (2004) proposed a conceptual framework to assess self-regulated learning in college students with MSLQ scales. The underlying assumption in this method is that self-regulation is an aptitude that students possess. The MSLQ consists of 6 motivational and 9 learning strategies subscales. The 6 motivation subscales measure intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy, and test anxiety. The 9 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 by using 2-tailed t-test with p-values of $<0.05$ were considered significant, as used in (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 by 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 MQLS scores are measures (dependent variables). The study compares the MSQL 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 MQSL scores instead. Therefore, it is reasonable to conclude that the results of the control and experimental groups can be validly compared.

#### 3.6.2.2. Trace data

Traces are defined as observable indicators about cognition that students create as they engage in a learning activity. They provide a high level of detail about learning strategies and self-beliefs about competencies and progresses (Zimmerman, 2008). In previous studies (Hadwin, Nesbit, Jamieson-Noel, Code, & Winne, 2007; Perry & 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 is computer logs, which can record students' learning activity in a computer-based learning environment. Trace data can capture the dynamic and adaptive nature of self-regulated learning. The data analysis of activity sequences from trace data may provide an online measurement for student self-regulated learning (Biswas, Jeong, Kinnebrew, Sulcer, & Roscoe, 2010).

In this research a trace method was used for measuring and exploring students' self-regulated learning skills by using the ePortfolio system. The information of activities is a critical part in trace data for self-regulated learning measuring. Based on the self-regulated learning strategies in (Zimmerman, 1989), self-regulated learning and metacognitive skills in (Boekaerts, 1999; Zimmerman, 2002), and the sub processes in self-regulated learning models (Pintrich, 2004; Zimmerman, 2000), we proposed a list of activities for log data.

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, 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, update progress
- Evaluate competency: When students set, update level of competency
- Set competency evidence: When students set output of activity when create/update artifacts
- Discussion: When students post, respond to discussion

• Review feedback: When students read discussions, view evaluations, view plans

Logged data are saved as XML files; each log item has the structure:

<log>

<who/>

<when/>

<activity/>

<course/>

<artifacts/>

</log>

The log file was analysed to examine the frequency and sequence of learning activities. Log data can show how students learn 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 learning with the ePortfolio system were identified.

Frequency counts and proportional frequencies provide important information about metacognitive control expressed in terms of tactics students engage while studying (Hadwin, Nesbit, Jamieson-Noel, Code, & Winne, 2007). Of course, diligence and heavy work do not mean self-regulated learning but frequency may show a person' motivation, volition, and emotion, which are linked to learning and achievement of a person in self-regulated learning (Boekaerts, 1999).

Theoretically, self-regulated learning strategies involve multiple activities to complete a common goal. Thus, it is important to examine transitions across fine-grained studying activities (Hadwin, Nesbit, Jamieson-Noel, Code, & Winne, 2007). Social learning psychologists view the structure of self-regulated learning in terms of three cyclical phases: forethought – before, performance – during, and self-reflection – after each learning effort (Zimmerman, 2002). In addition, the observations of instructors and content analysis guarantee that the activities of students in the ePortfolio system are related to the courses that students are enrolled. Thus, the mapping of transitions to student self-regulated learning is reasonable.

In graph theoretic statistics, density is a graph theoretic measure ranging from 0 to 1 that compare the number of occurred transitions to possible transitions (Winne, Gupta, & Nesbit, 1994). Lower values indicate predominant transitions occurring repetitively; higher values indicate much diversity in the types of transition with less regularity and repetition of patterns. Students with higher densities are experimenting with tactics and strategies. This means students are engaged in more metacognitive monitoring and active self-regulated learning (Hadwin, Nesbit, Jamieson-Noel, Code, & Winne, 2007).

In addition, a direct representation of internal states and related learning strategies can provide additional information useful in analyzing student learning performance. According to Biswas, et al., (2010), one way of representing internal states and their interactions is a hidden Markov model (HMM) (Rabiner, 1989). An HMM is a probabilistic automaton, which is made up of a set of states and probabilistic transitions between those states. In an HMM, the states of the model are hidden, meaning that they cannot be directly observed in the environment. Instead, they produce outputs (e.g., activity in the ePortfolio system) that can be observed.

Finally, time-based analysis was used to evaluate the changes in learning over time. The analysis of these change patterns allowed inferences to be made, such as how students' engagement in self-regulated learning improved, and how to foster their engagement.

# 4. Results

## 4.1. System evaluation

We received 25 responses via online survey. The means of scales represented in Table 4.1. Overall, the students agreed that they can use the system easily. They also agreed that they felt more motivated, they learned more actively, and they could control their learning with the system.

Table 4.1 Feedback results from students (N=25).

| Scales | Mean[a] |
|---|---|
| System usefulness | 5.09 |
| Information quality | 4.94 |
| Interface quality | 5.08 |
| The overall satisfaction | 5.02 |
| Effectiveness | 5.4 |

[a.] Based on a seven-point Likert scale with strongly disagree (1), and strongly agree (7)

The final exam grades of Data Structures and Algorithms class were collected. The mean grade of the control group is 4.35 (n=24), and mean grade of the experimental group (included students that used the ePortfolio system for learning) is 6.3 (n=14). The result of t-test show a significant difference between the groups with p=0.001.

Because all 18 students in Software development processes and tools class used the ePortfolio system for learning, we compared the final exam grades of this course with the final exam grades of this course in the previous year (as a control group). The mean grade of the control group is 6.8 (n=14), and mean grade of the experimental group is 7.3 (n=18). The result of t-test show that the difference is not significant (p=0.196), however, the experimental mean is higher.

## 4.2. The effects of the ePortfolio system on student self-regulated learning

### 4.2.1. Self-report data

With the SDPT class 18 responses were collected for both the 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 2-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 summarized in Table 4.2. Positive effects were reported in thirteen scales. The data shows that the use of the ePortfolio system might contribute to significant improvement 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, as shown in (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 by using unpaired 2-tailed t-test. The results were represented in Table 4.3. Table 4.3 shows 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 considered also. This comparison supports the results of the previous study in the SDPT class.

Table 4.2 The difference between pre-test and post-test in the SDPT course (N=18).

| Scales | Pre test, Mean (SD) | Post test, Mean (SD) | P |
|---|---|---|---|
| Rehearsal | 4.15 (1.17) | 4.71 (1.4) | **0.028**[a] |
| Elaboration | 4.31 (1.13) | 4.88 (1.3) | **0.004**[a] |
| Organization | 4.07 (1.16) | 4.44 (1.42) | 0.094 |
| Critical Thinking | 4.16 (1.03) | 5.02 (1.25) | **0.002**[a] |
| Metacognitive self-regulation | 4.19 (1.03) | 4.74 (1.2) | **0.001**[a] |
| Intrinsic Goal Orientation | 4.25 (1.32) | 4.68 (1.37) | 0.069 |
| Extrinsic Goal Orientation | 4.68 (1.1) | 4.97 (1.25) | 0.132 |
| Task Value | 4.81 (1.14) | 5.09 (1.15) | 0.057 |
| Control of Learning Beliefs | 5.29 (1.2) | 5.38 (1.06) | 0.681 |
| Self-Efficacy for Learning & Performance | 4.63 (1.11) | 4.66 (1.23) | 0.869 |
| Test Anxiety | 3.79 (1.56) | 3.52 (1.61) | 0.236 |
| Time/Study Environmental Management | 4.57 (0.92) | 4.53 (1.17) | 0.872 |
| Effort Regulation | 4.43 (1.33) | 4.63 (1.06) | 0.458 |
| Peer Learning | 4.98 (1.24) | 5.02 (1.4) | 0.772 |
| Help Seeking | 5.04 (0.97) | 4.88 (1.24) | 0.452 |

[a] $p<0.05$

Table 4.3 The mean differences of post-tests between control and experimental groups in the SDPT course.

| Scales | Control mean (SD) n=25 | Experiment mean (SD) n=14 | t | P |
|---|---|---|---|---|
| Rehearsal | 4.1 (1.22) | 4.7 (0.92) | -1.72 | 0.095 |
| Elaboration | 3.96 (1.14) | 4.94 (1.25) | -2.42 | **0.023**[a] |
| Organization | 3.84 (1.37) | 4.61 (1.13) | -1.87 | 0.07 |
| Critical Thinking | 3.84 (1.21) | 4.54 (1.4) | -1.59 | 0.126 |
| Metacognitive self-regulation | 3.84 (0.93) | 4.48 (0.82) | -2.24 | **0.032**[a] |
| Intrinsic Goal Orientation | 3.53 (1.16) | 4.96 (0.75) | -4.68 | **< 0.001**[a] |
| Extrinsic Goal Orientation | 4.53 (1.13) | 4.68 (0.98) | -0.43 | 0.67 |
| Task Value | 4.23 (1.34) | 5.17 (1.25) | -2.19 | **0.036**[a] |
| Control of Learning Beliefs | 4.47 (1.14) | 5.11 (0.92) | -1.9 | 0.066 |
| Self-Efficacy for Learning & Performance | 4.01 (0.99) | 4.75 (0.74) | -2.65 | **0.012**[a] |
| Test Anxiety | 4.18 (1.05) | 3.94 (0.98) | 0.69 | 0.493 |
| Time/Study Environmental Management | 4.07 (0.75) | 4.37 (0.48) | -1.49 | 0.144 |
| Effort Regulation | 3.88 (0.9) | 4.71 (0.61) | -3.43 | **0.002**[a] |
| Peer Learning | 3.73 (1.13) | 4.29 (1.5) | -1.2 | 0.244 |
| Help Seeking | 4.35 (1.25) | 4.88 (1.05) | -1.4 | 0.173 |

[a] $p<0.05$

For the second kind of evaluation in this study, the degrees of change of two groups were compared by using an unpaired 2-tailed t-test. Although not significant (t=-1.32; p=0.198), Table 4.4 shows that the experimental group is dominant on eleven scales. In addition, the experimental group had 5 scales with negative changes (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 & 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.

Table 4.4 The degree of changes between control and experimental groups in the SDPT course.

| Scales | Control mean of difference **(post-pre)** | Experimental mean of difference **(post-pre)** |
|---|---|---|
| Rehearsal | 0.75 | 0.125 |
| Elaboration | 0.038 | 0.517 |
| Organization | 0.038 | 0.275 |
| Critical Thinking | 0.215 | 0.16 |
| Metacognitive self-regulation | -0.013 | 0.283 |
| Intrinsic Goal Orientation | -0.058 | 0.275 |
| Extrinsic Goal Orientation | -0.058 | -0.25 |
| Task Value | -0.385 | 0.133 |
| Control of Learning Beliefs | -0.404 | -0.15 |
| Self-Efficacy for Learning & Performance | -0.207 | 0.013 |
| Test Anxiety | 0.062 | 0.04 |
| Time/Study Environmental Management | -0.173 | -0.075 |
| Effort Regulation | 0.115 | 0.65 |
| Peer Learning | -0.103 | -0.5 |
| Help Seeking | -0.212 | 0.15 |

The mean differences between pre-test and post-test scores for both groups were examined. A paired 2-tail t-test for each group was conducted. The data shows 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.

### 4.2.2. Trace data

Trace data was stored in XML files, each element containing information about a performed activity, such as participants, time, which activity, and which course. A log analyser 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 was examined because all students in this class used the ePortfolio system.

Frequency of learning activity. Overall, the data indicates considerable variance in the number of activities performed by each student (Mean=100.4, SD=68.3). Although all types of activities were performed by 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 shows that students rarely discussed learning with other students via the system. Discussion took 2.9%, and each student discusses 3.4 times on average. Table 4.5 shows the percentages of all activity types in the SDPT class.

Table 4.5 Percentages of activities in the SDPT class.

| Activity | % |
|---|---|
| Create Plan | 0.9 |
| Update Plan | 3.5 |
| Create Artifact | 5.3 |
| Update Artifact | 3.1 |
| Evaluate Activity | 24.4 |
| Evaluate Competency | 8 |
| Set Evidence | 5.9 |
| Discussion | 2.9 |
| Review Feedback | 46 |

The data suggests that further investigation of how the system encouraged students to engage in self-regulated learning activities are 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 between specific activities should be considered. Transition matrices and transition graphs were used to represent the patterns of learning activity.

In the transition matrix, each type of activity is represented as a row and as a column. Each cell contains a number that represents the percentage of transition from activity type in the row to activity type in the column, compared to a total number of transitions that start from the activity type in the row. A row shows the number of activity types that are connected from the activity type in the first cell; while the number of activity types that link to a given activity type is determined by a corresponsive column. The activity transitions of the SDPT class are shown in Table 4.6.

Table 4.6 The transition matrix of learning activity in the SDPT class.

| | Create Plan | Update Plan | Create Artifact | Update Artifact | Evaluate Activity | Evaluate Competency | Set Evidence | Discussion | Review Feedback |
|---|---|---|---|---|---|---|---|---|---|
| Create Plan | | 47.1 | 11.7 | | | | | | 41.2 |
| Update Plan | | 50 | 11.1 | 1.4 | | | | | 37.5 |
| Create Artifact | | 0.9 | 2.7 | 7.2 | 1.8 | | 76.6 | | 10.8 |
| Update Artifact | | 1.5 | 9.4 | 17.2 | 6.3 | | 18.8 | | 46.8 |
| Evaluate Activity | | | 0.2 | 0.2 | 81.8 | 0.4 | 0.4 | 0.4 | 16.6 |
| Evaluate Competency | | | | | 1.8 | 87.5 | 1.2 | | 9.5 |
| Set Evidence | | | 14.5 | 30.7 | 9.7 | | 4 | 3.2 | 37.9 |
| Discussion | | 1.7 | 4.9 | | 6.6 | | 1.6 | 8.2 | 77 |
| Review Feedback | | 2.7 | 7.3 | 0.7 | 7.2 | 2.2 | 1.9 | 5.2 | 72.8 |

Table 4.6 shows 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. they observe the discussions, evaluations, progresses, 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 (as shown in Table 4.5). Each directional line represents a transition from a type of activity to another activity or to itself with its percentage, as indicated in Table 4.6. Bold lines in the graph represent high frequency transitions. In general, the more active learners, the more 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 in Figure 4.1 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' engagement in self-regulated learning with a variety of tactics can be seen from the figure.

Time based analysis. The data was collected in three stages to check the change of activity distributions and transitions over time: the intervals were the first three weeks, the next two weeks, and the last three weeks. However, the second stage included a long holiday, and thus, this report focused on the first and the last stage.

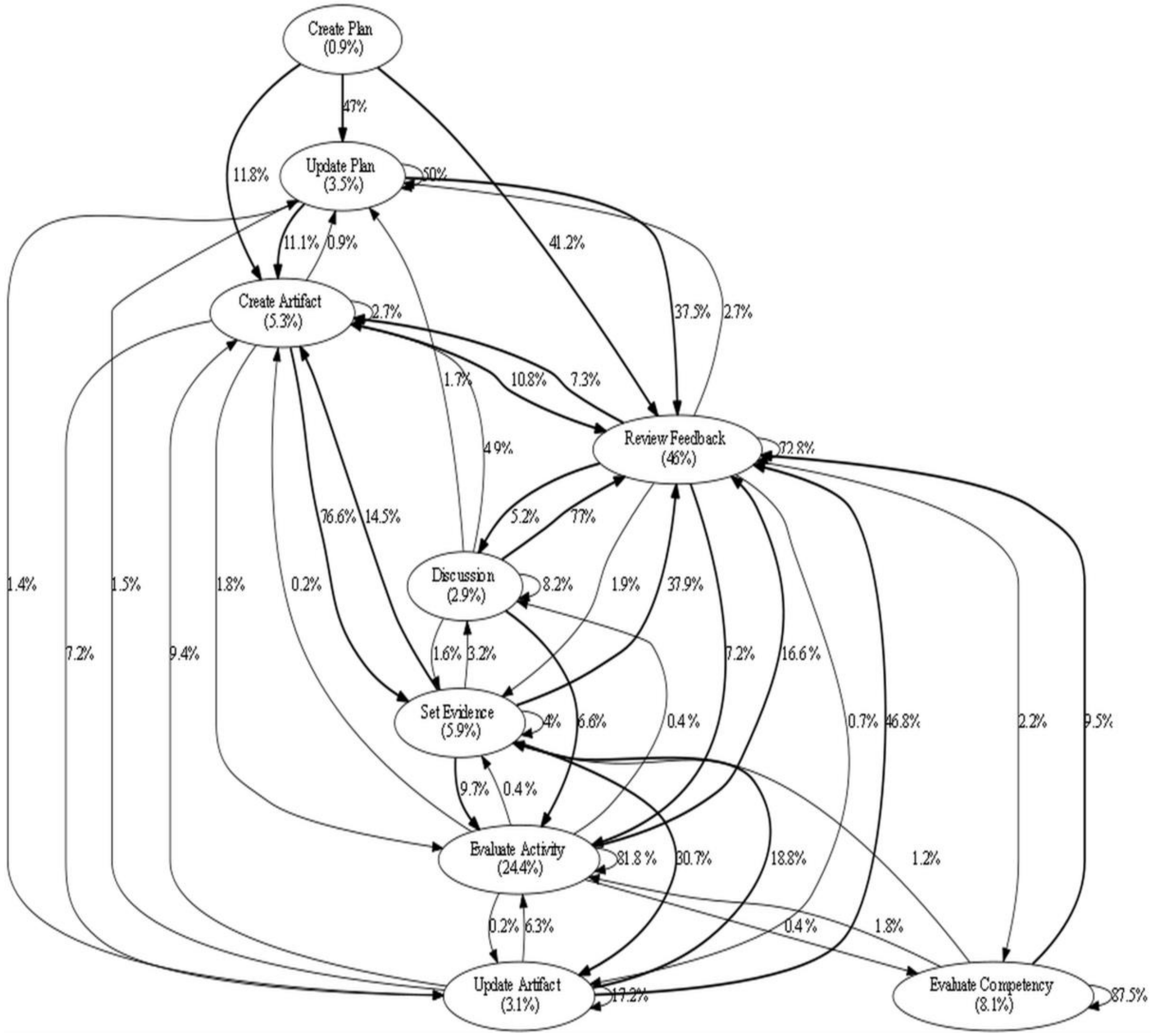



Figure 4.1 The transition graph of the SDPT class.

The chart in Figure 4.2 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.

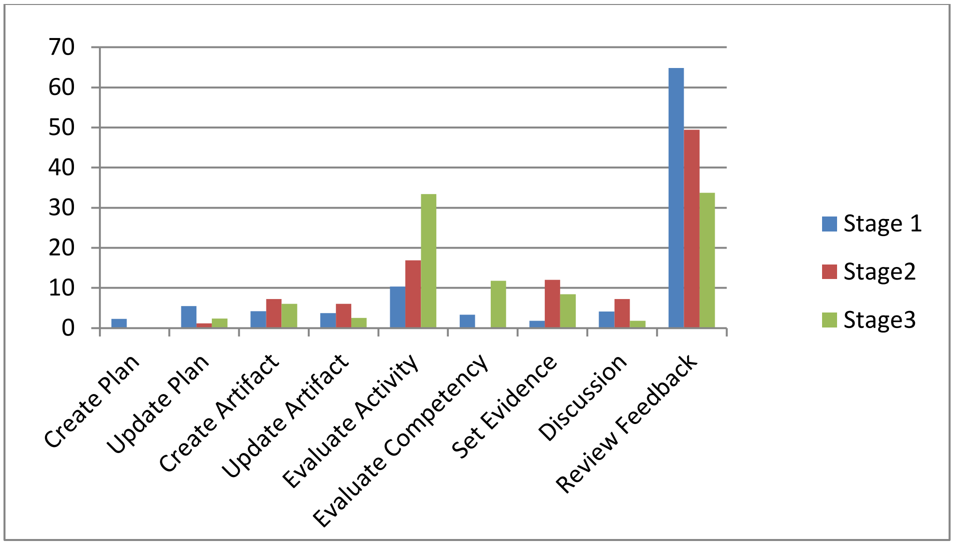



Figure 4.2 The percentages of activities in the SDPT class in three stages.

In addition, to examine the changes in transition patterns, two transition matrices of the first and third stages were created (Table 4.7 and Table 4.8). 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 higher quality artifacts in stage 3. The percentages of transitions that finished at Review Feedback decreased, whereas the number who 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, 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, 20014). In addition, the trace data shows 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 indicates that student self-regulated learning skills were improved over time by using the ePortfolio-based learning model.

Table 4.7 The transition matrix of the SDPT class in stage 1.

| | Create Plan | Update Plan | Create Artifact | Update Artifact | Evaluate Activity | Evaluate Competency | Set Evidence | Discussion | Review Feedback |
|---|---|---|---|---|---|---|---|---|---|
| Create Plan | | 47 | 11.8 | | | | | | 41.2 |
| Update Plan | | 51.2 | 12.2 | | | | | | 36.6 |
| Create Artifact | | 3 | 9.4 | 25 | 6.3 | | 25 | | 31.3 |
| Update Artifact | | 3.6 | 14.3 | 39.3 | | | 3.5 | | 39.3 |
| Evaluate Activity | | | | 1.3 | 73.7 | | | 1.3 | 23.7 |
| Evaluate Competency | | | | | | 80.8 | | | 19.2 |
| Set Evidence | | | | 41.6 | 8.3 | | 8.4 | 8.4 | 33.3 |
| Discussion | | 3.2 | | | 3.2 | | | 13 | 80.6 |
| Review Feedback | | 2.2 | 3.6 | 0.8 | 3.6 | 1.1 | 0.8 | 5.2 | 82.7 |

Table 4.8 The transition matrix of the SDPT class in stage 3.

| | Create Plan | Update Plan | Create Artifact | Update Artifact | Evaluate Activity | Evaluate Competency | Set Evidence | Discussion | Review Feedback |
|---|---|---|---|---|---|---|---|---|---|
| Create Plan | | | | | | | | | |
| Update Plan | | 51.7 | 10.3 | | 3.5 | | | | 34.5 |
| Create Artifact | | | | | | | 98.6 | | 1.4 |
| Update Artifact | | | 6.9 | | 13.8 | | 34.5 | | 44.8 |
| Evaluate Activity | | | 0.2 | | 83.8 | 0.5 | 0.5 | 0.3 | 14.7 |
| Evaluate Competency | | | | | 2.1 | 88.7 | 1.5 | | 7.7 |
| Set Evidence | | | 16 | 29 | 10 | | 4 | 2 | 39 |
| Discussion | | | 9.1 | | 9.1 | | | 4.5 | 77.3 |
| Review Feedback | | 3.6 | 11.9 | 0.3 | 11.7 | 3.8 | 3 | 4 | 61.7 |

# 5. Conclusions

## 5.1. Summary

In this research, the relations among ePortfolios, competency, and self-regulated learning were analyzed and synthesized. From these relations an integrated model was proposed by unifying self-regulated learning, ePortfolio, and competency models. With a deep and systematic analysis about the relations between the models and the results from the experiments we can claim that the enhancive relations these models are enhanced when they are integrated into a unique environment. Based on this model, we developed an ontological ePortfolio model for fostering self-regulated learning. Then, by using this model, an ePortfolio system was implemented to handle the issues of fostering self-regulated learning, for example, self-regulated learning principles representation and sharing, or self-regulated learning process implementation. The ePortfolio system was used in the first experiments for evaluations. The experiments and collected data show that the ontological model and the ePortfolio system contributed to the goal: fostering self-regulated learning.

We proposed an ontological ePortfolio model to foster student self-regulated learning. An ontology was developed in the OWL language based on the combination of self-regulated learning, ePortfolio, and competency models. The ontology can represent and share self-regulated learning principles; it provides a common vocabulary for modeling competencies, building academic programs and learning strategies. This model can be a guide to building learning support systems, developing teaching and learning models. The use of the ontologies and semantic web tools may provide advanced features for evaluating competency and performance, sharing resources, and seeking help.

By using the proposed ontological model, we also implemented an ePortfolio system, and used it for experimentations. The ontology was used as a meta-model for building the system, a shared vocabulary in ePortfolio based learning model, and a knowledge base of the system.

The first experiments were conducted in two courses at the Hoa Sen University, Vietnam. A PSSUQ based questionnaire and grades were used for system evaluation. The effects of the system on student self-regulated learning were evaluated by using MSLQ questionnaire, logged data. T-tests, the frequency and sequence of activities were used for data analysis.

The feedback results show that students were quite satisfied with the system. They agreed that the use of the ePortfolio system made them to be more motivated and active. They were able to observe their learning and regulate themselves in order to obtain better results. The grade data also indicates the use of the ePortfolio system impacted students' achievement positively.

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 in the courses. Indeed, the ePortfolio based learning model impacted 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 ($p<0.05$). 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 was used for behavior area of self-regulated learning. The findings explain that the uses of the ePortfolio system impact student self-regulated learning by fostering students' motivation and supporting students in performing and developing learning tactics and strategies.

Logged data illustrates that students in the experimental classes followed self-regulated learning principles and implemented self-regulated learning skills when using the ePortfolio system in the learning model. In addition, time-base analysis shows that the students' engagement in self-regulated learning improved through the first stage to the last stage, indicating that the students in these classes need time to use the system and practice the skills.

Data shows that the students in SDPT performed 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).

Finally, based on the way, the processes of development, the tools were used, and the results of the ePortfolio system, we can claim that the developed ontology was evaluated and it is a reliable ontology. Thus, it may be shared, reused in order to foster knowledge about self-regulated learning or build knowledge-based systems for fostering self-regulated learning.

### 5.2. Conclusions

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

The model and implemented system help us to handle the main issues of fostering self-regulated learning. 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 ePortfolio-based learning model positively affected students' self-regulated learning. The use of the self-regulated learning based ePortfolio systems contributed to positive changes in students' motivation and learning strategies.

The results also suggest that the effects of ePortfolio systems 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 ePortfolio systems to communicate, evaluate, and encourage students over time in order to improve the efficiency of the learning model. In addition, students are engaged in self-regulated learning when using ePortfolio systems in the learning model. In addition, time-base analysis shows that student engagement in self-regulated learning improved over time, indicating that students need time to practice and develop their skills.

Students need support in order to improve their self-regulated learning skills. 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 model, and self-regulated learning should be taken into account. With these stipulations, 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.

In this research, we introduce a novel ontology-based ePortfolio model for self-regulated learning that addresses both, the challenge of knowledge representation and sharing in self-regulated learning area and the development of self-regulated learning skills. Our approach provides ontological support for self-regulated learning strategy sharing and implementation by:

- Representing an integrated ePortfolio model and its components such as self-regulated models, competency assessment models, learning strategies, and learning resources as formal ontologies

- Sharing these ontologies directly and using them as common vocabularies and knowledge base in the ePortfolio environment

- Implementing ontological reasoning in the ePortfolio environment to support learners in planning, self-assessment, and resources selection.

- Introducing an ontology-based ePortfolio environment for practicing and linking self-regulated learning processes, and for modeling and measuring self-regulated learning.

Finally, the research presented in this thesis is significant for several reasons. Firstly, we treat understanding self-regulated learning as a process of mental ontology construction, which is supported by existing learning theories. Secondly, we provide a unified ontological representation for ePortfolio, competency, and self-regulated learning models, to support the development of a conceptual model that can promote self-regulated learning. Such representation allows learners to reason about the relations among learning plans, activities, learning outcomes, and learning resources. Thirdly, we developed an approach that integrates existing models into a unified learning model. Finally, we present a tool implementation to support the methodology and to demonstrate the applicability of our approach.

### 5.3. Limitations

There were some limitations in this research. Although the ontology was developed based on a deep analysis of related theories, the use of tools to check the consistence during the development process, and application-based evaluation, the ontology need a separate and formal evaluation phase before sharing and (re)using for application developments.

The role of the ontology as an element that capture and share self-regulated learning principles in the ePortfolio system is not clear. The instructors and students rarely used self-regulated learning tactics for the plans. A more relevant way for integrating self-regulated learning tactics and domain activities is needed. Overall, the use of the ontology for fostering self-regulated learning knowledge needs more experiments and evaluations.

The MSLQ surveys were conducted at the beginning and at the 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 even though the MSLQ has the potential for assessing self-regulated learning, there is a lack of research that uses MSLQ for this purpose.

The lack of time, number of courses, and the small number of respondents was other limitations. The experiments only were conducted with students in software engineering in a unique context, i.e. a Vietnamese university.

In addition, the learning data (for example, plans, activities, artifacts, evaluations, discussions) of each participant was not analysed in order to explore and evaluate the changes in self-regulated learning skills.

## 5.4. Future work

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. For example, using the ontology to share or teach about self-regulated learning theories before applying the ePortfolio-based learning model, conducting academic program-based experiments in a long period, the experiments should start from the beginning of the academic programs.

The instruments need to be test and improved, for example, Vietnamese version of MSLQ. 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. More specifically, self-regulated learning microanalysis (Cleary, Callan, & Zimmerman, 2012) will be used to assess self-regulated learning as a cyclical phenomenon.

The proposed model should be applied and evaluated in the knowledge-sharing field. Indeed, the ePortfolio system and learning model in this research may become a knowledge sharing system and knowledge sharing model, especially, knowledge sharing in educational contexts.

The ontology need to be evaluated more critically in order to improve its validity and reliability. The use of the ontology and semantic reasoning will be increased in order to provide more features for students to improve their awareness of their learning and competencies, support students in finding and selecting resources for their learning.

It is necessary to develop the guidelines for applying the model, the ePortfolio system in real contexts for teaching and learning in order to foster self-regulated learning and knowledge sharing.

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# Publications

Nguyen, L. T., & Ikeda, M. (2014). ePortfolio system design based on ontological model of self-regulated learning. *The 3rd International Conference on Learning Technologies and Learning Environments (LTLE2014).* Kitakyushu, Japan.

Nguyen, L. T., & Ikeda, M. (2014). Using ePortfolio system to foster student self-regulated learning. *The 22nd International Conference on Computers in Education (ICCE 2014).* Nara, Japan.

Nguyen, L. T., & Ikeda, M. (2014, accepted). The effects of ePortfolio-based learning model on student self-regulated learning. *Active Learning in Higher Education*.

# Appendices

**Appendix A:** The Motivated Strategies for Learning Questionnaire

This questionare is the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, & McKeachie, 1991) and its Vietnamese version. This survey uses a Likert scale from ‘‘1 not at all true of me’’ to ‘‘7 very true of me.’’

**1. Rehearsal**

- Khi học, tôi tự đọc đi đọc lại tài liệu

(When I study, I practice saying the material to myself over and over.)

- Tôi đọc lại nhiều lần những ghi chép trên lớp, và phần tự đọc của môn học

(When studying for classes, I read my class notes and the course reading over and over.)

- Khi học tôi ghi nhớ các từ khóa liên quan đến các khái niệm quan trọng

(I memorize key words to remind me of important concepts when I study.)

- Khi học tôi ghi lại danh sách các thu ật ngữ quan trọng và cố gắng nhớ

(When I study, I make lists of important terms and memorize the lists.)

**2. Elaboration**

- Khi học môn này, tôi tập hợp thông tin từ nhiều nguồn khác nhau như bài giảng, tài liệu tự đọc, thảo luận

(When I study for this class, I pull together information from different sources, such as lectures, readings, and discussions.)

- Tôi cố gắng kết nối những kiến thức trong một chủ đề với những kiến thức trong các môn học khác

(I try to relate ideas in one subject to those in other courses whenever possible.)

- Khi đọc ở lớp tôi cố gắng liên hệ nội dung tài liệu với những gì tôi đã biết

(When reading for classes, I try to relate the material to what I already know)

- Khi học tôi hay tóm tắt những ý chính từ tài liệu và các khái niệm từ bài giảng

(When I study, I write brief summaries of the main ideas from the readings and the concepts from the lectures.)

- Tôi cố gắng hiểu bài trong lớp bằng cách liên hệ những gì đọc trong tài liệu với các khái niệm từ bài giảng

(I try to understand the material in classes by making connections between the readings and the concepts from the lectures)

- Tôi cố gắng áp dụng những kiến thức từ phần tự đọc vào các phần khác của môn học như giờ giảng trên lớp, phần thảo luận

(I try to apply ideas from course readings in other class activities such as lecture and discussion.)

**3. Organization**

- Khi đọc tài liệu cho bài giảng, tôi ghi ra những ý chính vì nó giúp tôi suy nghĩ tốt hơn

(When I study the readings for a class, I outline the material to help me organize my thoughts.)

- Khi học tôi đọc qua các phần tự đọc, các ghi chú trên lớp và tìm ra những ý quan trọng nhất

(When I study, I go through the readings and my class notes and try to find the most important ideas.)

- Tôi tạo các sơ đồ, hay các bảng để tổ chức các tài liệu môn học

(I make simple charts, diagrams, or tables to help me organize course material.)

- Khi học tôi đọc lại các ghi chép trên lớp và tóm tắt các khái niệm chính.

(When I study, I go over my class notes and make an outline of important concepts)

**4. Critical thinking**

- Tôi luôn tự hỏi về những gì đọc được, nghe được ở môn này để chắc rằng nó có tính thuyết phục hay không

(I often find myself questioning things I hear or read in this classes to decide if I find them convincing.)

- Khi một lý thuyết, một giải thích hay một kết luận trong bài đọc hay được trình bày trên lớp, tôi cố gắng xem xét liệu có những bằng chứng thuyết phục hay không

(When a theory, interpretation, or conclusion is presented in class or in readings, I try to decide if there is good supporting evidence.)

- Tôi xem tài liệu môn học chỉ là điểm bắt đầu và cố gắng nâng cao những hiểu biết của riêng tôi về môn học

(I treat the course material as a starting point and try to develop my own ideas about it.)

- Tôi cố gắng phát huy những kiến thức của tôi có liên quan đến những gì tôi đang học trong lớp

(I try to play around with ideas of my own related to what I am learning in a class.)

- Bất cứ khi nào tôi đọc hay nghe về một khẳng định hay kết luận trong lớp tôi đều suy nghĩ về các khả năng khác có thể

(Whenever I read or hear an assertion or conclusion in classes, I think about possible alternatives.)

**5. Metacognitive self-regulation**

- Trong giờ học tôi hay bỏ sót những ý quan trọng vì thiếu tập trung.

(During class time I often miss important points because I'm thinking of other things)

- Khi đọc tài liệu tôi tự đưa ra các câu hỏi để giúp tôi tập trung

(When reading for classes, I make up questions to help focus my reading.)

- Khi đọc, nếu có điều gì chưa rõ tôi đọc lại và cố gắng hiểu

(When I become confused about something I'm reading, I go back and try to figure it out.)

- Nếu tài liệu khó hiểu tôi thay đổi cách đọc.

(If course materials are difficult to understand, I change the way I read the material)

- Trước khi đọc kỹ tài liệu tôi hay đọc lướt qua để biết các phần nội dung của nó

(Before I study new material thoroughly, I often skim it to see how it is organized.)

- Tôi tự đặt câu hỏi cho mình để đảm bảo là tôi đã hiểu tài liệu tôi đã học trong lớp

(I ask myself questions to make sure I understand the material I have been studying in class.)

- Tôi cố gắng thay đổi cách học để phù hợp với yêu cầu của môn học và cách dạy của giảng viên

(I try to change the way I study in order to fit the course requirements and instructor's teaching style.)

- Tôi hay thấy rằng tuy tôi đọc tài liệu nhưng tôi không hiểu hết nội dung của nó

(I often find that I have been reading for class but don't know what it was all about.)

- Tôi cố gắng nghĩ về một chủ đề và những gì sẽ học được từ nó thay vì chỉ đọc qua trong khi học

(I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying.)

- Khi học tôi cố gắng xác định những điều mà tôi chưa hiểu rõ

(When studying, I try to determine which concepts I don't understand well.)

- Khi học tôi xác định những mục đích cho bản thân nhằm định hướng các hoạt động học tập trong mỗi giai đoạn

(When I study, I set goals for myself in order to direct my activities in each study period.)

- Nếu tôi chưa hiểu rõ về điều gì khi ghi chép trên lớp, tôi sẽ tìm cách hiểu rõ ngay sau đó (If I get confused taking notes, I make sure I sort it out afterward)

**6. Intrinsic goal orientation**

- Tôi thích tài liệu học tập có tính thử thách vì tôi có thể học nhiều điều mới

(I prefer course material that really challenges me so I can learn new things.)

- Tôi thích tài liệu học tập kích thích sự ham hiểu biết mặc dù nó khó học hơn

(I prefer course material that arouses my curiosity, even if it is difficult to learn.)

- Điều tôi hài lòng nhất trong lớp học là sự cố gắng để hiểu nội dung bài giảng môt cách thấu đáo nhất có thể

(The most satisfying thing for me in classes is trying to understand the content as thoroughly as possible.)

- Khi có cơ hội, tôi chọn những bài tập mà qua đó tôi có thể học thêm kiến thức mặc dù có thể điểm thấp

(When I have the opportunity, I choose course assignments that I can learn from even if they don't guarantee a good grade.)

**7. Extrinsic goal orientation**

- Đạt điểm cao là vấn đề quan trọng nhất đối với tôi lúc này

(Getting a good grade is the most satisfying thing for me right now.)

- Điều quan trọng nhất đối với tôi lúc này là cải thiện điểm tích lũy, do đó điều tôi quan tâm nhất ở môn này là đạt điểm cao

(The most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade.)

- Nếu có thể, tôi muốn điểm môn này cao hơn hầu hết các bạn khác

(If I can, I want to get better grades in this class than most of the other students.)

- Tôi muốn học tốt môn này bỡi vì tôi muốn chứng tỏ khả năng của tôi với gia đình, bạn bè, công ty, và những người khác

(I want to do well in this class because it is important to show my ability to my family, friends, employer, or others.)

**8. Task value**

- Tôi nghĩ tôi có thể sử dụng những gì học được trong môn này cho các môn học khác

(I think I will be able to use what I learn in this course in other courses.)

- Việc nghiên cứu các tài liệu của lớp này là quan trọng đối với tôi

(It is important for me to learn the material in this class.)

- Tôi rất quan tâm đến lĩnh vực kiến thức mà môn này cung cấp

(I am very interested in the content area of this course.)

- Tôi nghĩ tài liệu của lớp này rất hữu ích cho tôi

(I think the material in this class is useful for me to learn.)

- Tôi thích các chủ đề của môn học này

(I like the subject matter of this course.)

- Việc hiểu các chủ đề của môn học này rất quan trọng đối với tôi

(Understanding the subject matter of this course is very important to me.)

**9. Control of learning beliefs**

- Nếu học đúng cách, tôi có thể học tài liệu của môn này

(If I study in appropriate ways, then I will be able to learn the material in this course.)

- Là sai lầm của bản thân nếu tôi không học tài liệu trong môn này

(It is my own fault if I don’t learn the material in this course.)

- Nếu cố gắng tôi sẽ hiểu tài liệu môn học

(If I try hard enough, then I will understand the course material.)

- Nếu tôi không hiểu tài liệu môn học, là bởi vì tôi không cố gắng hết sức

(If I don’t understand the course material, it is because I didn’t try hard enough.)

**10. Self-efficacy for learning and performance**

- Tôi tin là tôi sẽ đạt điểm xuất sắc trong môn này

(I believe I will receive an excellent grade in this class.)

- Tôi chắc chắn là tôi có thể hiểu nội dung khó nhất trong các phần tự đọc của môn này

(I’m certain I can understand the most difficult material presented in the readings for this course.)

- Tôi tin chắc là có thể hiểu các khái niệm cơ bản được dạy trong môn này

(I’m confident I can understand the basic concepts taught in this course.)

- Tôi tin chắc là có thể hiểu nội dung phức tạp nhất được trình bày bỡi giảng viên trong môn này

(I’m confident I can understand the most complex material presented by the instructor in this course.)

- Tôi tin chắc là có thể hoàn thành xuất sắc bài tập và bài thi môn này.

(I’m confident I can do an excellent job on the assignments and tests in this course)

- Tôi mong là sẽ học tốt môn này

(I expect to do well in this class.)

- Tôi chắc chắn sẽ thành thạo các kỹ năng được dạy trong môn này

(I’m certain I can master the skills being taught in this class.)

- Tính đến khó khăn của môn này, giảng viên, và kỹ năng của bản thân, tôi nghĩ tôi sẽ học tốt môn này

(Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class.)

**11. Test anxiety**

- Khi làm bài kiểm tra tôi nghĩ tôi đã làm bài rất tệ so với các bạn khác

(When I take a test I think about how poorly I am doing compared with other students.)

- Khi làm bài kiểm tra tôi nghĩ về các câu hỏi trong các phần khác của bài kiểm tra mà tôi không thể trả lời

(When I take a test I think about items on other parts of the test I can't answer.)

- Khi làm bài kiểm tra tôi nghĩ về một kết quả thất bại

(When I take tests I think of the consequences of failing)

- Tôi lo lắng, cảm giác buồn chán khi thi

(I have an uneasy, upset feeling when I take an exam.)

- Tôi cảm thấy tim đập nhanh khi thi

(I feel my heart beating fast when I take an exam.)

**12. Time/study environment management**

- Tôi thường xuyên học ở nơi mà tôi có thể tập trung

(I usually study in a place where I can concentrate on my course work.)

- Tôi tận dụng tốt thời gian học tập

(I make good use of my study time.)

- Tôi thấy khó khăn trong việc theo sát một lịch học

(I find it hard to stick to a study schedule.)

- Tôi có một nơi dành riêng cho học tập

(I have a regular place set aside for studying.)

- Tôi đảm bảo là tôi hoàn thành các bài đọc, bài tập hàng tuần của môn học

(I make sure I keep up with the weekly readings and assignments for my courses.)

- Tôi đi học đầy đủ trên lớp

(I attend class regularly.)

- Tôi thấy rằng tôi chưa dành nhiều thời gian cho học tập vì nhiều hoạt động khác

(I often find that I don't spend very much time on school work because of other activities.)

- Tôi hiếm khi có thời gian đọc lại các ghi chép hay bài đọc trước kỳ thi

(I rarely find time to review my notes or readings before an exam.)

**13. Effort regulation**

- Tôi luôn cảm thấy lười biếng hay buồn chán khi học đến nỗi tôi từ bỏ trước khi hoàn thành việc gì đó theo kế hoạch

(I often feel so lazy or bored when I study that I quit before I finish what I planned to do.)

- Tôi chăm chỉ học tốt ngay cả khi tôi không thích những gì chúng ta đang làm

(I work hard to do well even if I don't like what we are doing.)

- Khi môn học khó khăn, tôi từ bỏ hoặc chỉ học những phần dễ

(When course work is difficult, I give up or only study the easy parts.)

- Ngay cả khi môn học chán ngắt và không thú vị tôi vẫn cố gắng hoàn thành

(Even when course materials are dull and uninteresting, I manage to keep working until I finish.)

**14. Peer learning**

- Khi học tôi thường xuyên cố gắng giải thích nội dung môn học cho các bạn trong lớp

(When studying for a class, I often try to explain the material to a classmate or a friend.)

- Tôi cố gắng làm việc với các bạn để hoàn thành bài tập

(I try to work with other students to complete the course assignments.)

- Tôi thường xuyên dành thời gian để thảo luận nội dung học tập với một nhóm các bạn trong lớp

(When studying for a class, I often set aside time to discuss the course material with a group of students from the class.)

**15. Help seeking**

- Ngay cả khi có vấn đề với môn học tôi cố gắng làm việc một mình

(Even if I have trouble learning the material in a class, I try to do the work on my own, without help from anyone.)

- Tôi nhờ giảng viên làm rõ những vấn đề chưa hiểu

(I ask the instructor to clarify concepts I don't understand well.)

- Khi không hiểu nội dung môn học, tôi nhờ sinh viên khác giúp đỡ

(When I can't understand the material in a course, I ask another student in this class for help.)

- Tôi cố gắng tìm ra những bạn trong lớp mà có thể giúp đỡ tôi khi cần

(I try to identify students in my classes whom I can ask for help if necessary.)

**Appendix B**: System Evaluation Questionnaire

This questionnaire was developed based on the Post Study System Usability Questionnaire (PSSUQ) (Lewis, 2002), and a Likert scale from ‘‘1 strongly disagree’’ to ‘‘7 strongly agree’’.

1. Nói chung, tôi hài lòng với mức độ dễ dàng khi sử dụng hệ thống

(Overall, I am satisfied with how easy it is to use this system.)

2. Đơn giản để sử dụng hệ thống

(It was simple to use this system.)

3. Tôi có thể hoàn thành các thao tác sử dụng hệ thống một cách hiệu quả

(I could effectively complete the tasks and scenarios using this system.)

4. Tôi có khả năng để hoàn thành các thao tác sử dụng hệ thống nhanh

(I was able to complete the tasks and scenarios quickly using this system.)

5. Tôi có khả năng để hoàn thành các thao tác sử dụng hệ thống một cách hiệu quả

(I was able to efficiently complete the tasks and scenarios using this system.)

6. Tôi cảm thấy thoải mái khi sử dụng hệ thống

(I felt comfortable using this system.)

7. Dễ dàng tìm hiểu cách sử dụng hệ thống

(It was easy to learn to use this system.)

8. Tôi tin tôi có thể nhanh chóng sử dụng hệ thống một cách hiệu quả

(I believe I could become productive quickly using this system)

9. Hệ thống cung cấp thông báo lỗi rõ ràng

(The system gave error messages that clearly told me how to fix problems)

10. Khi gặp lỗi tôi có thể khắc phục nhanh và dễ dàng

(Whenever I made a mistake using the system, I could recover easily and quickly)

11. Thông tin (như hướng dẫn sử dụng, thông báo) được cung cấp rõ ràng

(The information, such as on-line help, on-screen messages and other documentation provided with this system was clear)

12. Dễ dàng tìm kiếm thông tin tôi cần

(It was easy to find the information I needed)

13. Thông tin cung cấp cùng hệ thống dễ hiểu

(The information provided for the system was easy to understand)

14. Thông tin giúp tôi hoàn thành các thao tác hiệu quả

(The information was effective in helping me complete the tasks and scenarios.)

15. Thông tin được tổ chức trên giao diện của hệ thống rõ ràng

(The organization of information on the system screens was clear)

16. Giao diện của hệ thống hợp lý

(The interface of this system was pleasant)

17. Tôi thích sử dụng giao diện của hệ thống

(I liked using the interface of this system)

18. Hệ thống này có tất cả các chức năng mà tôi mong muốn

(This system has all the functions and capabilities I expect it to have.)

19. Nói chung tôi hài lòng với hệ thống này

(Overall, I am satisfied with this system.)

20. Việc sử dụng hệ thống tạo thêm động lực học tập cho tôi

(The use of the ePortfolio system motivate me in learning)

21. Hệ thống giúp tôi chủ động hơn trong học tập

(The system makes me to be more active in learning)

22. Hệ thống giúp tôi theo dõi được tình hình học tập và tự điều chỉnh cách học để có kết quả tốt hơn

(The system helps me observe and regulate my learning to have better results)