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Effects of Semantic Web Based Learning on Pre-service Teachers' ICT Learning Achievement and Satisfaction

Halit Karalar[1], Agah Tugrul Korucu[2]

[1]Department of Computer Education and Instructional Technology, Faculty of Education, Mugla Sitki Kocman University, Mugla, Turkey

[2]Department of Computer Education and Instructional Technology, Faculty of Ahmet Kelesoglu Education, Necmettin Erbakan University, Konya, Turkey

Correspondence: Halit Karalar, Department of Computer Education and Instructional Technology, Faculty of Education, Mugla Sitki Kocman University, 48000, Mugla, Turkey

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Abstract

Although the Semantic Web offers many opportunities for learners, effects of it in the classroom is not well known. Therefore, in this study explanations have been stated as how the learning objects defined by means of using the terminology in a developed ontology and kept in objects repository should be presented to learners with the aim of facilitating significant learning through a pedagogical agent developed in the light of cognitive theories, and subsequently the effects of Semantic Web Based Learning (SWBL) on the learning performance and satisfaction of pre-service teachers in Information and Communication Technologies (ICT) course are explored. This study employed the quasi-experimental research method, and the participants were 98 pre-service teachers. The experimental group was taught by SWBLE, while the control group was taught by Traditional Teaching (TT). The study results indicated the following: (a) regarding learning achievements, pre-service teachers who learned via the SWBL demonstrated higher learning performance than pre-service teachers who received the TT; (b) on the learning satisfaction survey, pre-service teachers who learned via the SWBL were largely satisfied with the SWBL that was designed purposefully for this study. Theoretical and practical implications of the results are discussed.

Keywords: semantic web based learning, pre-service teacher, ICT

1. Introduction

Such factors as the developments in ICT, widespread use of the Internet, and easy access to the learning material available on World-Wide Web (Web) from anywhere and at anytime have led the Web to become a significant platform for learning. Web is constantly improving, and the periods of improvements are designated in different ways. While the period of Web 1.0 was only readable Web, Web in the period of Web 2.0 turned into an easy-to-use and writable and readable platform on which users could create, share and manage the contents actively thanks to Web tools without having the ability to make programs. The contents created on various platforms by millions of people every day have caused an enormous increase in the size of the contents on the Web (Aksac, Ozturk, & Dogdu, 2012), adversely affecting the management of Web contents and accessibility to the desired contents on the Web. The case being so, it is becoming difficult for students to find appropriate learning objects (Sudhana, Raj, & Suresh, 2012), which are scattered on the Web, depending on their interests and needs. To this problem is added the assumption that one-size-fits-all, that all students learn in the same way from a single content, which has become a chronic problem for all Web-based learning settings, in other words, the problems of the inability to individualize education. One of the different approaches developed to solve these problems is Semantic Web (Web 3.0).

Berners-Lee defines Semantic Web as "not a separate Web but an extension of the current one, in which information is given a well-defined meaning, better enabling computers and people to work in cooperation" (Berners-Lee, Hendler, & Lassila, 2001, p.35). According to Semantic Web vision, thanks to well-defined Web contents, both a global database will be achieved by semantically connecting disconnected Web pages and the contents of these Web sites will become more understandable by machines (computers, cellular phone, television, etc.) and by humans. Certain standards and technologies must be specified for this vision to be realized. These standards and technologies can be seen in Fig. 1.

URI (Uniform Resource Identifier), IRI (Internationalized Resource Identifier) and XML (eXtensible Markup Language), which occupy the lowest layer in the structure in which Semantic Web technologies and standards are presented in layers, are today's Web standards. IRI is used for international character sets to be used and URI for definition of uniform Web sources. XML is a standard developed in 1996 by World Wide Web Consortium (W3C) to create files that machines can read and process (Bray, Paoli, & Sperberg-McQueen, 1998).

RDF (Resource Definition Framework) is a model developed by W3C to describe and process metadata. RDFS or RDF Schema is an extendable information presentation language used in creating taxonomy and vocabulary to be used to define RDF sources and in describing classes and correlations between them, defining characteristics and connecting them to the classes. OWL (Web Ontology Language) is a popular language used to develop ontology. Compared to RDF Schema, OWL makes it possible to express more complex and rich correlations (Yu, 2011). SPARQL (Sparql Protocol and RDF Query Language) is an RDF query language used by agent software for data mining on the contents available and integrated on the Web. Rule layer aims at presentation and exchange of rules. Unifying logic layer is mostly related to inference process. Proof layer deals with the accuracy of the resources accessed on the Web and on what proof the new information obtained during the inference process is based. Crypto layer deals with data security. Trust layer deals with digital signatures and whether the data source is reliable or not. User Interface & Application layer is the layer at which users interact with software agents.

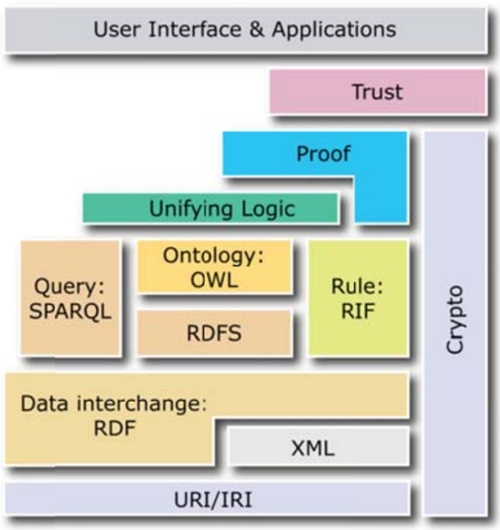

Figure 1. Semantic Web layer cake (Retrieved from http://www.w3.org/2007/03/layerCake.png).

Wiley (2001, p.7) defines learning objects as "any digital resource that can be reused to support learning". According to Mohan & Brooks (2003, p.195), "a learning object is a digital learning resource that facilitates a single learning objective and which may be reused in a different context". Because developing learning objects is costly and time-consuming, reusing learning objects has gained importance. Since learning objects are stored on the Web in a disorganized way, it is essential to describe learning objects to make it possible to reuse and share them (Sabau, 2008). Metadata, known as data about data, is used while describing learning objects. In order to reuse learning objects in different systems, it is important for learning objects to be standardized (Mohan & Brooks, 2003).

Several metadata standards for educational Learning Objects have been proposed by various research organizations to improve learning objects reusability, but the most popular metadata standard in educational domain is IEEE Learning Object Metadata (LOM). The manifest file in which there are physical sources that constitute learning objects at this standard and in which upper data definitions are made is composed by using XML technology (Mohan, 2004). XML presents file formats that can be transferred on the Web smoothly, read and automatically processed by computers. On the other hand, because knowledge and semantics cannot be described in XML files that can be read and processed by computers, these files cannot be understood by computers (Sudhana et al., 2012). In other words, XML merely identifies the format of the file, but doesn't deal with its interpretation by machines (Devedžić, 2006). This affects reusing and sharing learning objects adversely due to inefficiency of text-based search engines. It is recommended to use Semantic Web technologies and ontologies to resolve this problem (Mohan & Brooks, 2003).

Ontologies are the backbone of the Semantic Web due to their presentation of information, their search engines and several useful properties of them for smart systems (Devedžić, 2006). Ontologies describe all vocabulary included in a domain and the relationships between them (Kasimati & Zamani, 2011) which consist of a set of entities, relations, instances, functions, and axioms (Sudhana et al., 2012). This vocabulary point outs which entities will be represented, how they can be grouped, and what relationships connect them together (Segaran, Evans & Taylor, 2009). Noy & McGuinness (2001, p.1) identified five reasons for the development of ontology:

- to share common understanding of the structure of information amongst people or software agents;
- to enable reuse of domain knowledge;
- to make domain assumptions explicit;
- to separate domain knowledge from the operational knowledge;
- to analyse domain knowledge.

A lot of technology is required for Semantic Web applications to be developed. According to Maedche & Staab (2001, p.72), "Semantic Web relies heavily on formal ontologies to structure data for comprehensive and transportable machine understanding". On the focus of the research in which Semantic Web technologies and ontologies are used are producing learning objects that are reusable and sharable (Henze, Dolog, & Nejdl, 2004; Verbert, Klerkx, Meire, Najjar, & Duval, 2004; Gasević, Jovanović, Devedžić, & Bošković, 2005; Jovanović, Gašević, Verbert, & Duval, 2005; Knight, Gaševi, & Richards, 2006; Sudhana et al., 2012; Raju & Ahmed, 2012), ontology development (Amorim, Lama, Sánchez, Riera, & Vila, 2006), authoring environment (Aroyo, King, Drive, & Salem, 2004; Dicheva & Dichev, 2006), personalised learning (Chen, 2009; Dhuria & Chawla, 2014), semantic e-learning framework (Huang, Webster, Wood, & Ishaya, 2006), assessment and feedback (Castellanos-Nieves, Fernández-Breis, Valencia-García, Martínez-Béjar, & Iniesta-Moreno, 2011; Papasalouros, Kotis, & Kanaris, 2011; Sánchez-Vera, Fernández-Breis, Castellanos-Nieves, Frutos-Morales, & Prendes-Espinosa, 2012). However, most of these studies consist of the suggestions for a model or a framework rather than applications that reach end users. This is called an image problem by Carmichael & Jordan (2012). Although the Semantic Web offers many opportunities for learners, pre-service teachers and in-service teachers (Anderson & Whitelock, 2004; Kasimati & Zamani, 2011; Czerkawski, 2014), effects of it in the classroom is not well known.

Movement of Enhancing Opportunities and Improving Technology, known as FATIH in Turkey, is among the most significant educational investments of Ministry of Turkish National Education. With this project, 42 thousand schools and 570 thousand classes will be equipped with the latest information technologies and will be transformed into smart classes (Ministry of Turkish National Education, 2012). For the FATIH project to be successful, it is of great importance for the teachers to make effective use of ICT and for candidate teachers to be trained in a way to use such technologies. Yet, neither practical applications regarding the learning settings of Semantic Web technologies nor enough studies that examine the effect of SWBL on the ICT learning achievement and satisfaction level of candidate teachers are sufficiently encountered. The current study attempted to bridge the gaps by exploring the effects of SWBL on the learning performance and learning satisfaction of pre-service teachers in ICT course. The research questions proposed in this study are as follows:

- Did the learning achievement of pre-service teachers who learned via SWBL differ from those who received TT?
- What is learning satisfaction level of pre-service teachers who learned via SWBL after performing ICT course?

2. Method

2.1 Participants

This study was conducted in the spring semester of 2013-2014 academic year. The participants in this study were two classes comprised of 98 pre-service teachers at Necmettin Erbakan University Education Faculty of Ahmet Kelesoglu in Turkey. Two experimental educational methods were employed: the experimental group who learned via SWBL, while the control group received TT. The experimental group numbered 52 pre-service teachers, while the control group numbered 46. The pre-service teachers who participated in this study had computer courses in the fall semester.

2.2 SWBLE Environment

According to Devedžić (2006, p.89) "pedagogical agents are a kind of intelligent software agents, hence they are autonomous software entities, capable of performing specific tasks". Pedagogical agents could provide the learners with a semantically enriched learning environment to facilitate learning. In this way, a deeper understanding of the concepts used in the subject field on learners' part can be achieved (Lytras & Naeve, 2006). On the other hand, it is not sufficient for pedagogical agents only to access to learning objects that are in learning object repositories and which are semantically defined and to offer learning objects to learners. At the same time, it is of great importance to improve pedagogical agents in the light of the question, how the human mind works and how we can adapt pedagogical agents to enhanced human learning.

Cognitive theories that focus on how information is received, organized, stored, and retrieved by the mind dwell on making knowledge meaningful and on helping the learners to organize the existing and new information in their mind (Ertmer & Newby, 2013). According to the information processing model, one of the most important stages for learning is the stage of transferring prerequisite information related to the new information from the long-term memory to the short-term memory (Gagné, Briggs, & Wager, 1992, p.9-10). Additionally, according to Mayer (2001, p.12) "humans focus on the meaning of presented material and interpret it in light of their prior knowledge" and "learning is promoted when existing knowledge is activated as a foundation for new knowledge" (Merrill, 2002, p.44-45). For this reason, the existing prior knowledge of the learners should be planned, taking the mental structures or schemas into account for an effective instruction (Ertmer & Newby, 2013), and it should be presented in such a way to correlate the new knowledge to this already existing knowledge, in meaningfulness (Schunk, 2012). Another important stage in information processing is expectancies. The fact that the learners have expectancies as to what the learners can do with the knowledge they have learnt may affect how the knowledge is obtained, how it is coded in the memory and how it will be turned into performance (Gagné et al., 1992).

Through the SWBL environment developed in the study, not only access by the pre-service teachers to learning objects is achieved but also prerequisite learning objectives of the objectives the pre-service teachers have chosen and the access to the learning objects regarding these objectives are presented for meaningful learning to take place. Also, the pre-service teachers are informed about which learning will become difficult in the future unless they cannot learn the objectives they have chosen.

In this study, first an ontology called OntoExcel was developed in the study. Extra properties and classes can be easily added later to the developed ontologies. Therefore, the ontology has been developed in quite a simple way (Fig. 2). The OntoExcel ontology developed through Protégé software has three classes, namely LearningObject, Objective and Topic. The classes and the Data Properties that these classes have are shown in UML diagram. Object Properties are shown together with the arrows showing relations between classes. The Object Properties are at the same time Inverse properties with each other (isLoOf with hasLO, hasPrerequest with isPrerequestOf, isObjectiveOf with hasObjective).

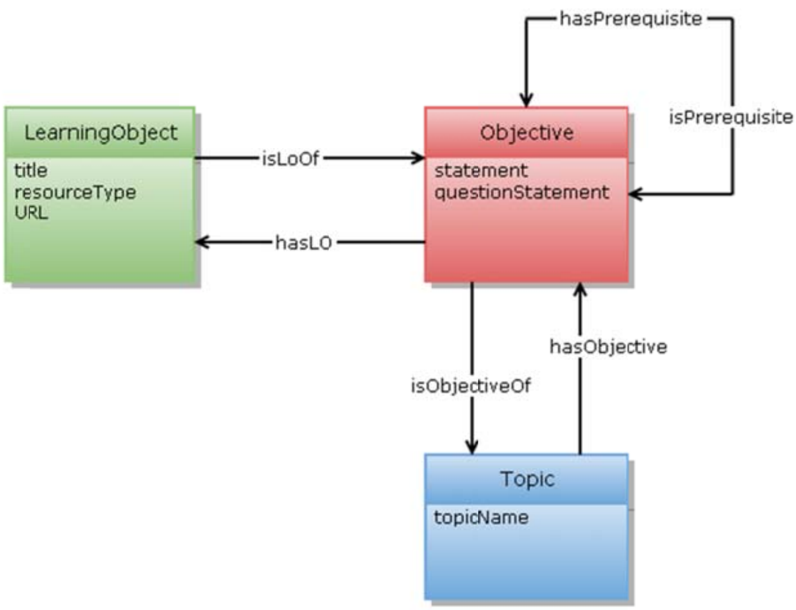

Figure 2. OntoExcel ontology.

The stages proposed by Noy & McGuinness (2001) were followed while developing ontology. The first of these stages is "determine the domain and scope of the ontology" (p.5). For this, it must be defined to which questions the ontology will give answers. The ontology developed should pedagogically give answers to the following questions:

- What are spreadsheets' topics (Section A);
- What are the objectives of a chosen topic? (Informing learner of the objective for creating expectations) (Section B);
- With regarded to a chosen objective:
- What are the prerequisite objectives of this objective? (Section C)

- What are the learning objects of a chosen prerequisite objective? (Section D) (recalling of prerequisite learning);
- What are the learning objects of this objective? (presenting content) (Section E);
- Which objects will become difficult in the future unless they cannot learn this objective? (creating expectations) (Section F).

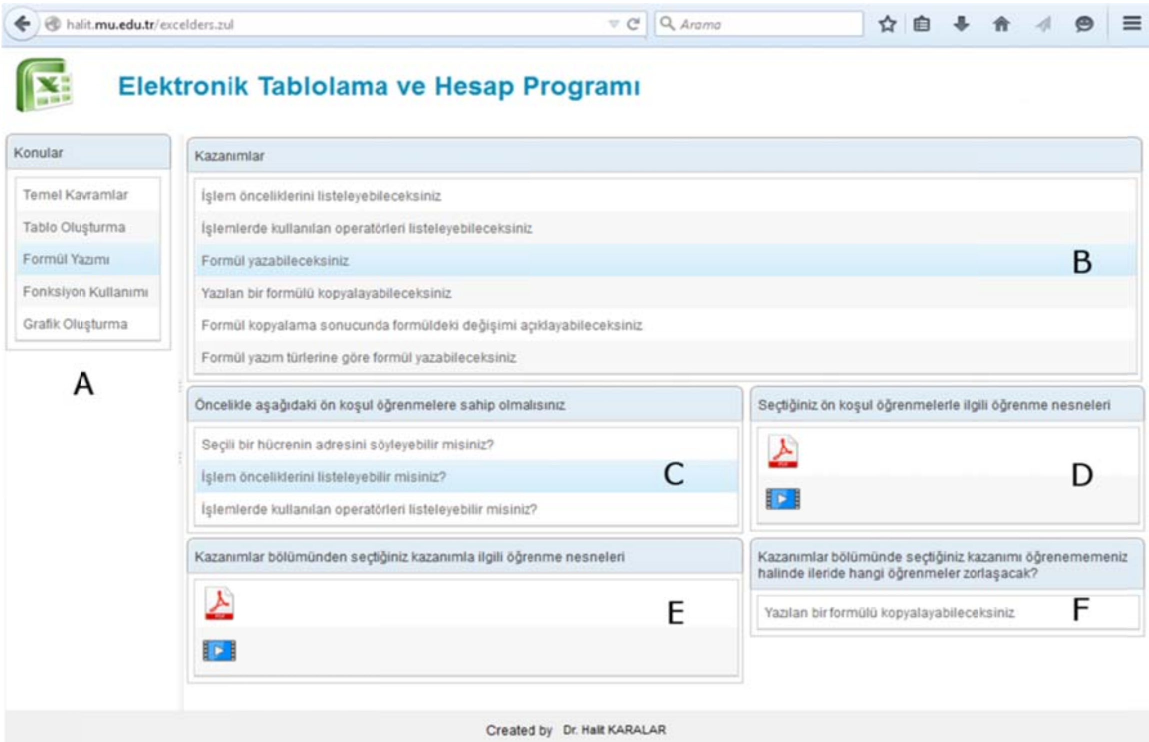

Figure 3. Semantic web based learning environment.

European Computer Driving Licence (ECDL, 2014) spreadsheets base module, lesson curriculum and course books were examined, and 5 topics and 37 objectives related to these topics were determined. It is possible that an objective may have prerequisite objectives or the objective itself may be prerequisite of other objectives. Therefore, first an objective analysis was conducted. The prerequisite objective analysis was carried out for each objective with the question of which objective or objectives must be learnt beforehand in order for this objective to be learnt. Also, a posterior objective analysis was conducted with the question of which objects will become difficult to learn in the future unless the objectives can be learnt. Afterwards, a total of 74 learning objects that were created through PowerPoint videos of lectures with voice-over in background and printed document version of the PowerPoint presentation were developed for each objective, and these objects were uploaded onto a server; and thus a learning object repository was constructed. The metadata definitions of learning objects were stated by means of the terminology developed in a separate RDF file (LO.RDF) and again loaded together with OntoExcel ontology file (OntoExcel.OWL) onto the same server. Depending on the answers given by the developed ontology, a SWBL environment in which learners interact with pedagogical agent was developed (Fig. 3.) and loaded onto same server.

Firstly, a subject is chosen in SWBL environment (as shown in Section A) and pedagogical agent displays a list of outcomes related to the selected subject (as shown in Section B). Then, one of the objectives is determined and pedagogical agent lists related prerequisite objectives (as shown in Section C), learning objects (as shown in Section E) and possibly difficult objectives in case selected objective is not facilitated (as shown in Section F). If any prerequisite objective is selected, pedagogical agent lists relevant learning objects (as shown in Section D). Learning objects are the Power Point Presentation videos of lectures narrated by the researchers with their printed version on pdf document. Teacher candidates were guided to study learning objects on selected prerequisite objectives first of all, and accordingly study learning objects on selected objective. Teacher candidates have learnt all subjects and the related objectives through following the steps mentioned above.

The following open source software and frameworks were used while developing a SWBL environment (pedagogical agent).

- Protégé is used for the creation of OntoExcel;
- HP JENA Java framework is used for developing Semantic Web application;
- Eclipse IDE is used for Java coding;
- ZK framework is used for Java Web application or user interface;
- Apache Tomcat is used for Web server.

The OntoExcel.OWL file and the LO.RDF file were read with the pedagogical agent developed by using Jena framework, and a graph structure was obtained. Pedagogical answers that the ontology would give were obtained through SPARQL. These answers were shown in letters in Table 1.

Table 1. Semantic web based learning environment.

Topics	Spreadsheets Objectives	
Basic Concepts Create Table *Formulas* Functions Charts A	You will be able to list process priorities You will be able to list the process operators used in spreadsheets *You will be able to write a formula* You will be able to copy a written formula You will be able to explain the change in the formulae as a result of formula copying You will be able to write formula according to the types of formula writing	B
	First of all, you must have the following prerequisite learning;	
	Can you tell the address of a selected cell? *Can you list process priorities?* Can you list the operators used in the processes?	C
	The learning objects related to the prerequisite objective that you have chosen	D
	The learning objects related to the objective that you have chosen from the objectives section	E
	Which learnings will become difficult in the future unless they learn the objectives you have chosen from the objectives section?	
	You will be able to copy a written formula	F

2.3 Instrument

2.3.1 ICT Achievement Tests

This study used ICT achievement tests to determine the learning achievements of the pre-service teachers. The achievement tests were used as pre-test and post-test. The pre-test and post-test consisted of 40 multiple-choice items about ICT course. The tests were reviewed and edited by three experts on the subject.

In achievement tests development process, two tests with 60-items that were adapted to critical objectives were developed, and they were implemented as the pilot implementation to 90 pre-service teachers who had taken the course previously. After the pilot study, the items whose item discrimination index was lower than 0.40 and item difficulty index was lower than 0.40 or higher than 0.60 were eliminated from the test and the final version of the test was developed. For internal consistency, the overall KR-20's a value of the first test results was 0.87, and that of the second test results was 0.83, thereby indicating that the two test papers had superior internal consistency. The first test was applied as the pre-test and the second test was applied as the post-test in the study. Regarding content validity, achievement tests were prepared, based on objective analysis made by researchers, to effectively test the learning status of the pre-service teachers.

2.3.2 Learning Satisfaction Survey

This study used online learning satisfaction survey to determine the learning satisfaction of the pre-service teachers in the experimental group. At the end of the course, they were asked to complete the survey containing 7 Likert-based questions created specific to the course and two open-ended questions. The Likert-based questions asked them to rank statements on a scale of 1 (strongly disagree) to 4 (strongly agree). The open-ended questions were stated to elicit specific responses on what they liked and did not like about the SWBL.

2.3.3 Procedure

The study lasted for 4 weeks between March 2014 and mid-April 2014, and 16 lessons (55 min/lesson) of experimental ICT teaching were conducted for the two classes. The experimental group went through SWBL, while the control group received the TT. While SWBL group learned through PowerPoint videos of lectures with voice-over and documents of this PowerPoint presentation, TT group learned through same lecture based PowerPoint presentations. One week prior to the official teaching, pre-service teachers in both groups completed the achievement pre-tests and experimental group completed orientation for the use of the SWBL environment. After the formal experiment, both groups completed the learning achievement post-test and experimental group completed the learning satisfaction survey.

2.3.4 Data Analysis

The learning achievements pre-test and post-test were collected from the participants in the study. SPSS 20.0 statistical software was adopted to conduct statistical analysis, using a statistical significance of 0.05. Because the participants were selected using purposive sampling rather than random sampling, to reduce experimental error during the teaching experiment, the learning achievement pre-test scores of the two groups were used as covariates during the analysis of covariance in addition to the control variables in the experiment, thereby eliminating differences between the groups. This study employed the one-way ANCOVA to process the results of the learning achievement. Descriptive analysis for Likert-based questions were calculated to present a sense of overall opinion for the SWBL and content analysis was applied while examining the themes in the open-ended responses to determine general feelings about the SWBL.

3. Results

3.1 Learning Achievement

In this study, the experimental group consisted of 52 pre-service teachers, and the control group comprised 46 pre-service teachers. The experimental group learned via SWBL and the control group received the TT. Both groups completed the ICT learning-achievement pre-test and post-test before and after the experimental teaching. The mean of the pre-test and post-test scores in the experimental group are 7.24 and 33.58, while they are 5.09 and 26.00 for the control group.

This study examined the effects of the SWBL on pre-service teachers' learning achievements. To eliminate the moderating variables formed based on preexisting experiences, the achievement pre-test and post-test were respectively used as the covariate and the dependent variable for conducting one-way ANCOVA. The results of the within-group regression coefficient homogeneity test were $F = 2.213,\ p = .140 > 0.05$, which did not reach significance. This supported the assumptions regarding the homogeneity of the covariance for the within-group regression coefficient.

After eliminating the effects of the pre-test score (covariate) on the post-test score (dependent variable), the effects of the independent variables on the dependent variables were as follows: $F = 55.627,\ p = .000 < 0.05$ *and* $\eta 2 = 0.369$, which reached significance. After eliminating the pre-test effects of the two participant groups, the post-test score exhibited a significant difference because of the different teaching methods. The experimental group received an adjusted post-test score of 33.11, which was significantly higher than the 26.52 score of the control group. This indicated that the learning achievements of the pre-service teachers who learned via SWBL were significantly superior to those of the pre-service teachers who received the TT.

3.2 Learning Satisfaction

A learning-satisfaction survey was completed by the experimental group after ICT course. Table 2 presents a summary of the statistical results. The results showed that the pre-service teachers in the experimental group were satisfied with SWBL. They exhibited a high mean regarding the items in the survey; "Prerequisite objectives related to selected objective helped me learn the topic." (3.38), "Supposing not learning selected objective, stating future objectives getting possibly more difficult helped me learn the topic." (3.21), "The PDF files based on objectives helped me learn the topic." (3.27), "The Power Point Presentations videos helped me learn the topic." (3.33), "The Web environment was easy to use." (3.33), "I would rather my other courses be on the same Web environment, too." (3.08) and "The learning environment was fun and amusing." (3.19). Overall, the responses were positive, indicating that most students were satisfied with the SWBL.

Table 2. Statistical summary of the learning satisfaction survey

	Question	Mean	S.D.	SA (%)	A (%)	D (%)	SD (%)
1.	Prerequisite objectives related to selected objective helped me learn the topic.	3.38	0.53	40.38	57.70	1.92	
2.	Supposing not learning selected objective, stating future objectives getting possibly more difficult helped me learn the topic.	3.21	0.54	26.92	67.30	5.78	
3.	The PDF files based on objectives helped me learn the topic.	3.27	0.49	28.85	69.23	1.92	
4.	The Power Point Presentations videos helped me learn the topic.	3.33	0.58	36.54	61.54		1.92
5.	The Web environment was easy to use.	3.33	0.58	38.46	55.77	5.77	
6.	I would rather my other courses be on the same Web environment, too.	3.08	0.59	19.23	71.15	7.70	1.92
7.	The learning environment was fun and amusing.	3.19	0.49	23.07	73.08	3.85	

SA, strongly agree; A, agree; D, disagree; SD, strongly disagree.

Certain themes regarding what pre-service teachers liked and did not like about the SWBL emerged in the open-ended questions and the themes and the sample responses were presented in the Table 3.

Table 3. Themes: Pre-service teachers liked and did not liked about SWBL

	Themes (frequency)	Samples on students' responses
likes	facilitating learning (32)	"It was very wise to be directed another subject first while studying subjects to make me learn." "Presenting the content related to prerequisite objectives eased my learning." "Prior knowledge eased my learning. The topic subject based presentation videos contributed to my learning." "It was satisfying in terms of content. It was more fruitful to explain content in details and core."
	learning anywhere anytime (19)	"It is very easy to reach the content wherever there is Internet connection." "Not needing school environment due to listening the course wherever we want." "Being able to reach the content. Accessibility is very likely." "IT was a positive feature that I could reach the content without time and place limitation."
	learning just-in-time (17)	"It enabled us to reach the content in a short time." "It prevented time loss. It helped us to learn the content faster." "It enabled me to reach the content in shorter time." "I could access to what I wanted to learn in Web environment faster than Google search. It eased to reach the content."
	easy to use (12)	"It was easy to use. Not being complex, the environment was efficient. I could understand even in my first use." "It was easy to use." "It was easy and practical."
	meaningful learning (8)	"The content was prepared step by step and with justification so that students did not have any question in mind." "That the content was based on prior knowledge and there were related recommendations presented a meaningful learning." "The course was become meaningful."
	reliable (5)	"The Web environment is fine, content is fruitful and it comes in order." "It is very reliable and far beyond infollution." "It's being reliable eases our works."
dislikes	decreasing communication in class (4)	"I think it restricts the classroom communication among students." "There is no opportunity for us to consult to instructor when we face with a problem."
	necessity for Internet access (2)	"I could not benefit from it since there were not Internet connection and computer in dormitory environment." "It was a negative feature for me that it was working with Internet connection. There is no Internet connection where I stay. I could not use it whenever I wanted."

The features pre-service teachers like were categorized into the themes as; facilitating learning, learning just-in-time and anywhere anytime, easy to use, meaningful learning and reliable. That there are many opinions frequencies in themes have resulted from pre-service teachers' stating opinions more than once. The features they did not like were categorized into themes as; decreasing communication in class and necessity for Internet access.

4. Discussion

The objective of this study was to explore the effects of SWBL on the learning performance and satisfaction of pre-service teachers in ICT concepts. Learning achievement tests were used to determine the effects of the SWBL on the learning achievements. Online learning satisfaction survey was used to determine the learning satisfaction of the pre-service teachers in the experimental group. Learning objects were prepared in accordance with the spreadsheets objectives. During the course, educators aided pre-service teachers, increased their involvement, and assisted them in completing tasks. Although the teaching methods differed, the two groups used similar learning resources.

The achievement tests indicated that the learning performance of the pre-service teachers who learned via SWBL in learning the ICT spreadsheets course was significantly higher than that of the pre-service teachers who received the TT. This indicates that SWBL assists pre-service teachers with learning ICT course. The results of this study indicated that SWBL is beneficial to pre-service teachers' learning achievement regarding ICT spreadsheets course. There is not enough learning environment at the expected level for learners due to reasons as lack of development in standard ontologies, incapability of different systems working at the same time, continuity in developing Semantic Web technologies and standards. Studies mostly suggest a model or a framework. Studies highlighting such learning environments effects with experimental researches are restricted. For instance; learning objects for 8th grade Science and Technology course, Pressure subject's objectives were prepared by Karalar (2013) and therefore; these objects could be examined semantically through using Semantic Web technologies and ontologies at the same time. In the results of the study, it was revealed that students learn better with SWBL that determined the prior learning deficiencies and helped to satisfy the needs with directions.

The satisfaction survey results showed that most pre-service teachers in the experimental group showed a high level of satisfaction with the SWBL. The pre-service teachers like the facilitating learning, learning just-in-time and anywhere anytime, easy to use, meaningful learning and reliability features of SWBL. The disliked features are decreasing communication in class and necessity for Internet access. These results show that SWBL can provide students with easy and meaningful learning process; is a reliable learning environment and easy to use; and reach the content at anytime and anywhere. When all these themes are examined, it can be inferred that SWBL is an applicable technology agent which can be adopted by teachers and students at the same time to facilitate learning in-and-out of classroom environment. It also enhances teachers and students' learning maintenance throughout their educational life which is a part of life-long learning.

The results of this study indicate that SWBL are beneficial to pre-service teachers' learning achievement regarding ICT spreadsheets course, and they were largely satisfied with the SWBL. The researches highlighted that the classrooms should be equipped with new technologies for better projects concerning technology integration in education, however, this simply was not efficient (Ertmer, 2005; Kohler & Mishra, 2005; Kay, 2006; Özdemir & Kılıç, 2007). Moreover, technologies in effective classroom use develops slowly and is not performed in the desired level (Kay, 2006; Liu, 2013). In order for teachers to apply these technologies in their classrooms effectively, they should first have the necessary knowledge and skills. Therefore, SWBL can be used as an alternative learning environment to TTs for pre-service teachers to be equipped with the necessary knowledge and skills to apply technology in their classrooms effectively.

Because of factors of time and location, this study employed a small number of samples. Thus, for generalization of the data, it would be useful to conduct similar studies at different types of schools, in different classes, at different levels of education, in different periods and with more students. There are few studies in the field of education in which Semantic Web and ontologies are used together with a view towards application. In Maddux & Johnson's study (as cited in Czerkawski, 2014, p.144), Semantic Web is still not well known outside of computer science and artificial intelligence circles. For this reason, particularly the studies to be conducted by researchers working in the field of education will play a significant role in the Semantic Web becoming widespread and in increasing the number of the applications that will be accessed by learners.

In this study, pre-service teachers can access to the objective they have chosen and the related prerequisite objectives as well as the learning objects related to them at the SWBL. In this way, an opportunity is offered to pre-service teachers to make up for their educational shortcomings, and teaching is personalized. All in all, considering such individual differences as learning styles of students, their cognitive styles, their preference for the media, etc., new research conducted to develop agent software that can offer learning objects automatically will pave the way to developing smarter learning environments. Moreover, it would be useful to examine the cognitive load of the students working at a SWBL their level of disorientation.

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