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How do the cognitive load, self-efficacy and attitude of pre-service teachers shift in the multimedia science learning process?

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The aim of this study is to investigate pre-service teacher's cognitive load types (intrinsic load-IL, extraneous load-EL, and germane load-GL), academic achievements, and affective characteristics (attitude and self-efficacy) at two stages of experimental learning processes. The first and the second groups used explanatory instructional multimedia science simulations (EImms-1 and EImms-2), and the third group used actual science laboratory experiments (ASLE). In the first stage, the pre-service teachers in the EImms-1 and 2 groups performed 20 different science experiments, and the students in the ASLE group performed the same experiments in the science laboratory. In the second stage, the groups were switched. The results show that the pre-service teachers in the EImms groups have significantly higher self-efficacy, more positive attitude, greater academic achievement, and lower IL, EL, and GL scores than those in the ASLE group. Also, the results are discussed with regard to cognitive load perspective.

Key words: Cognitive load, self-efficacy, attitude, simulation based science experiments, real (wetlab) science experiments, academic achievement, pre-service teachers.

INTRODUCTION

Cognitive load, multimedia and learning

Scientists working on learning or psychology conduct research on the proper model or theory to explain the vital question of "How do people learn?" A theory known as "Cognitive Information Processing" was proposed to explain the human learning system. Working within this theoretical framework, most scientists (Atkinson and Shiffrin, 1968; Lord and Maher, 1990) believe that the human information processing system consists of propellant components and three main information stores: (a) sensory motor, (b) working or short-term memory, and (c) long-term memory. During the learning process, people first use sensory perceptions to select and collect part of the available information and secondarily use short-term or working memory (WM), which has both limited capacity 7±2 chunk (Miller, 1956; Neisser, 1967) and durability (Peterson and Peterson, 1959), by categorizing the

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information to organize it. Lastly, organized knowledge is stored in schemata in the long-term memory (LTM), which has unlimited capacity (Baddeley, 1992).

On the other hand, over the last two decades, cognitive load theory (CLT) (Paas et al., 2003a; Paas et al., 2004; Sweller, 1988; Sweller and Chandler, 1994; Sweller et al., 1998; van Merriënboer and Sweller, 2005) has provided guidelines for the design of effective instruction that is compatible with the human cognition system. According to CLT, cognitive load (CL) occurs during learning processes in individuals' working memory (WM). Furthermore, there are three main sources of CL: intrinsic load (IL), extraneous load (EL), and germane load (GL) (Kalyuga, 2009a; Moreno and Park, 2010; Paas et al., 2003b; Sweller et al., 1998). Concept of IL is defined as a load by the difficulty of the materials, which has been supported by various researchers in the field such as IL is derived from the inherent complexity of the materials to be learned (Ayres, 2006; Backmann, 2010; Paas et al., 2010; Sweller et al., 1998; Whelan, 2007) and the number of elements that must be simultaneously processed in working memory (Park et al., 2011; Sweller and Chandler, 1994). EL is undesirable and ineffective in learning and is caused by poorly designed learning tools (Ayres and Paas, 2007; Paas et al., 2003a; Van et al., 2006). GL is related to learning because it is the result of devoting cognitive resources to schema acquisition and automation to process new information and integrate it into existing knowledge structures (Homer et al., 2008; Moreno and Park, 2010).

CLT has been a particular focus of different types of researches on computer-based instruction and multimedia learning (Homer et al., 2008; Kalyuga, 2007; Scheiter et al., 2009; Wouters et al., 2008; Zhang et al., 2011) which is defined as constructing a concrete mental model by means of using pictorial and verbal elements (Mayer, 2005) during the learning process. One of the topics of such researches is explanatory instructional multimedia science simulations (EImss), which are usually used for real-life problems (Huk and Ludwigs, 2009) as well as learning or discovering scientific facts in classrooms or laboratories (Ploetzner and Lowe, 2004). EImss are also used for practicing important skills (Holzinger et al., 2009; Limniou et al., 2009) such as pilot training, the most difficult types of medical training, and physics experiments to virtually explain scientific facts to learners. The theories -Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2005; Mayer and Moreno, 2002) and Cognitive Load- (see Sweller et al., 1998) reveal such vital principles as multimedia, coherence, modality, redundancy, contiguity for effective instruction and material design in CTML, separation of learning content and considering learners' readiness for IL, reducing EL, and increasing GL for the effective instruction in CLT. Overall, the results of the applied high quality scientific researches based upon these principles illustrate the effectiveness of multimedia elements and tools on learning (Eilam and Poyas, 2008; Harskamp et al., 2007; Mayer, 2009, 2014; Schnotz and Bannert, 2003). In addition, scientific facts are vitally important for students in terms of their ability to clearly understand natural phenomena as well as constructing scientific knowledge. To illustrate, in science courses, teachers mostly use an essential method known as actual science laboratory experiments (ASLE). However, in ASLE, learners are exposed to more CL because of such factors as performing the required procedures and interacting with other people, especially when wait time is constrained (Kalyuga, 2009b); whereas EImss provide opportunities for the students to examine real-life simulations to understand abstract concepts or scientific rules via pictures, animations, shapes, or graphics (Boyle, 2004). Moreover, these simulations enhance learners' motivation (de Freitas and Oliver, 2006) and help learners control and prepare their cognitive resources through virtual pre-laboratory applications before performing ASLE (Limniou et al. 2009). Despite some well-known specifications of EImss, it is not clear how pre-EImss experiments applied before the ASLE may affect the learners' types of CL (IL, EL, and GL) or motivational characteristics such as self-efficacy beliefs or attitude toward the learning process.

Self-efficacy beliefs, attitude and achievement

Various behaviors and actions are initially shaped in human mind. Cognitive constructions then serve as guides for action or behavior in the development of proficiencies. In fact, people's beliefs concerning their efficacy influence the various situations and scenarios they construct. People with a high sense of efficacy may construct cognitive simulations as successful guidelines for their own performance (Bandura, 1997). Perceived self-efficacy refers to one's beliefs about his/her capabilities to produce effects (Bandura, 1994). Moreover, one's concept of self-efficacy is essential for adapting and using one's own cognitive structures to achieve the performance and skills (Bandura, 1997), which are also supported by the further researches (Tsai et al., 2011; van Dinther et al., 2011). On the other hand, students' attitudes should be taken into account in terms of learning environments (Frenzel et al., 2007). Generally, the concept of attitude is defined as "a summary evaluation of a psychological object captured in such attribute dimensions as good-bad, harmful-beneficial, pleasant-unpleasant, and likable-dislikable" (Ajzen, 2001, p.28) and it is also related to learners' perceptions through cognitive, affective, and behavioral processes (Sun, 2009). If students have both positive self-efficacy (Govaere et al., 2011) and a positive attitude in learning processes, they may learn better and will more easily attain additional learning (Osborne et al., 2003).

One of the criteria that should be taken into account in the learning processes is academic achievement, which is based upon whether the students achieve the goals of the course or learning subject. Moreover, it is related to cognitive ability (Preckel et al., 2011), perceived learning environment (Frenzel et al., 2007), motivational factors (Hollender et al., 2010; Schnotz and Kürschner, 2007) and self-efficacy as well as attitude.

Although the affective characteristics of learners such as attitude and self-efficacy are central to the learning process, they have not been clarified in terms of their relations to CL (Paas et al., 2005). Given these scientific facts, in the current study, we attempted to determine the relationships among the students' cognitive load types (IL, EL, and GL) and their self-efficacy, attitude, and academic achievement in the learning process via EImss and ASLE methods.

Purpose of the study

The simulations have been used frequently in science education, including physics, chemistry, biology, and other subjects. In this study, we developed and used 20 EImss for science laboratory experiments during a "Science and Technology Laboratory Application – II" course. The main purpose of this study was to determine how IL, EL, and GL change in EImss and ASLE environments and how pre-service teacher's science teaching self-efficacy, their attitude toward science teaching, and academic achievement are affected in these processes.

Research questions

a) Are there any significant differences between the pre-service teacher's IL, EL, and GL in terms of the EImss and ASLE groups in the first stage of the research?
b) Are there any significant differences between the pre-service teacher's science academic achievement scores in terms of the EImss and ASLE groups in the first stage of the research?
c) Are there any significant differences between the pre-service teacher's Science Teaching Self-Efficacy (STSE) scores in terms of the EImss and ASLE groups in the first stage of the research?
d) Are there any significant differences between the pre-service teacher's Attitude toward Science Teaching (AtST) scores in terms of the EImss and ASLE groups in the first stage of the research?
e) Are there any significant differences among IL, EL, and GL scores of the pre-service teachers in the EImms-1 & 2 and ASLE groups regarding the first and the second stage of the research?
f) What are the views of the pre-service teachers in the EImms-1 & 2 and ASLE groups related to methods used in the first stage of the research?

METHODS

In this study, a mixed-methods approach was used. In the initial phase, the experimental design included a pre-test and post-test group. At the end of the first stage, student interviews were considered. During the first stage of the research process, quantitative data were analyzed using ANOVA and ANCOVA techniques. Then, the qualitative data obtained from the interviews of the pre-service teachers were analyzed in terms of themes and sub-themes. The design of the study is shown in Table 1. The study was conducted in the Faculty of Education Primary School Teaching department at a university in southern Turkey during the spring semester. This research was carried out within the "Science and Technology Laboratory Application – II" course. A total of 234 undergraduate pre-service teachers participated in the lesson. This study sample included (n=105) randomly selected pre-service teachers. These pre-service teachers were randomly divided into three groups. The first group was named EImss-1, the second group EImss-2, and the third group ASLE-Control. A total of 14 pre-service teachers were interviewed. Half of them were from the EImss groups (1-2), and the others were from the ASLE group. The qualitative data obtained from the interview were analyzed by an inductive content analysis technique. Furthermore, in the present study, two research groups were used for the experimental condition (EImms-1 & 2). The structure of the study design with two experimental groups gives opportunity for comparing the results of the groups powerfully in terms of different research variables.

The present research was carried out in two stages (stage-1, stage-2), and each stage was completed over seven weeks. Both groups had taken an introductory seminar before starting the research process. Detailed information about the processes performed by all groups in each stage is explained in the following section.

General procedure for two stages

All of the pre-service teachers in the research groups (EImss-1, EImss-2, and ASLE) attended an introduction seminar (80 min.). The content of the seminar covered subjects such as "what the aim of the research is, how the research processes will be carried out, and what the specifications of the data collection tools are." Moreover, the purpose of the seminar was to ask the pre-service teachers to focus on the research applications. After the completion of the seminar, the first stage of the research was started. Furthermore, in the second stage of the research, the groups were switched. Pre-service teachers in the EImss-1&2 groups individually performed WetlabE(s) and the pre-service teachers in ASLE group individually used the SimbSLE(s) experiments.

Procedure for EImss groups

Pre-service teachers in the EImss-1 and EImss-2 groups individually performed 20 different SimbSLE (Figure 1) designed by the researchers in a computer laboratory. Before the process was started, a science academic achievement test (SaaT), science teaching self-efficacy scale (STSE), and attitude toward science teaching scale (AtST) were applied as pre-tests. At the end of the stage, the same measurement tools were applied as post-tests. Moreover, in this process, each week, pre-service teachers individually performed three/four SimbSLEs in the computer laboratory over an 80-min period, and their IL, EL, and GL were measured with questions (see Questions Q_{IL}-Q_{EL}-Q_{GL} sub-section).

Procedure for ASLE group

The pre-service teachers who were in the ASLE group individually performed 20 different WetlabE (Figure 1) in the science and technology laboratory on the same content as the EImss-1 and

Table 1. Experimental research design.

			Stage-1		Stage-2
Groups	Introductory seminar	pre-test (academic achievement, attitude, and self-efficacy)	Science experiments (1-20) CL measurement (IL, EL, and GL)	post-test (academic achievement, attitude, and self-efficacy) and Interviews	Science experiments (1-20) CL measurement (IL, EL, and GL)
EImss-1 EImss-2	X	X	SimbSLE based laboratory experiments	X	WetlabE based science laboratory experiments
ASLE (Control)			WetlabE based science laboratory experiments		SimbSLE based laboratory experiments

X: Shows the introductory seminar and data collecting tolls conducted with the students in the groups.

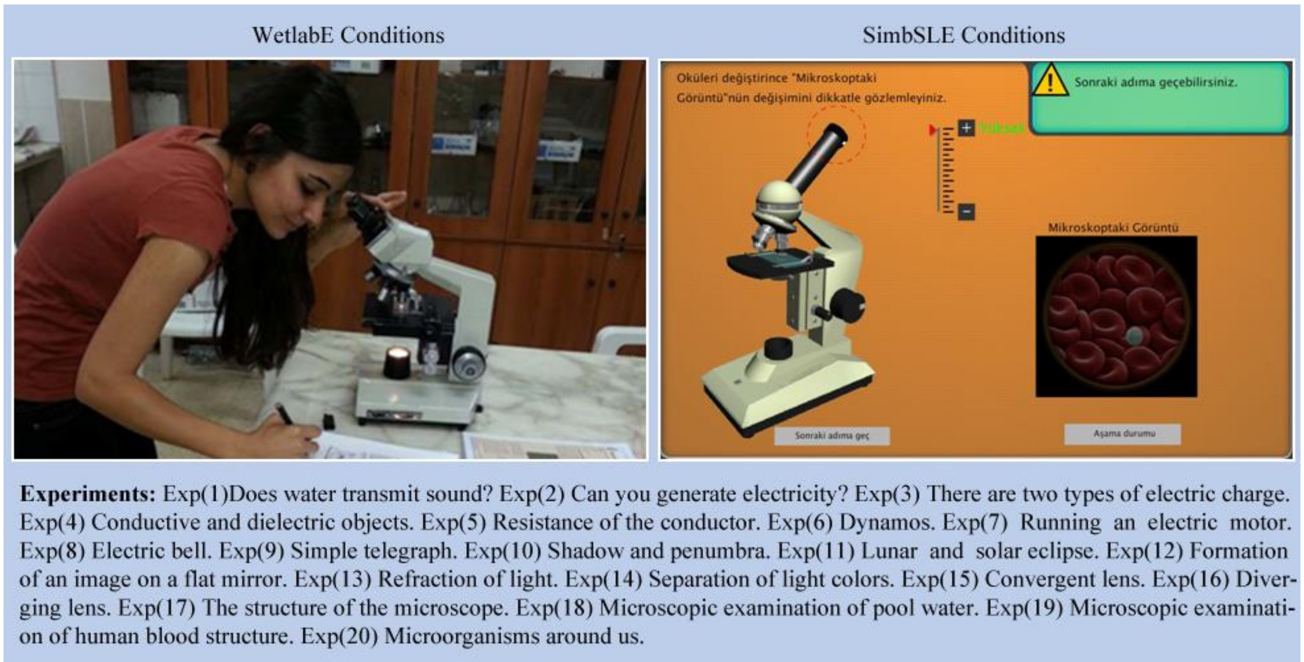

Figure 1. Title of the experiments and the conditions of WetlabE and SimbSLE environments.

EImss-2 groups. Moreover, the same measurement tools were used as -pre and post-tests like in EImss groups. Throughout this process, each week, the teachers applied three/four WetlabEs in the science and technology laboratory during an 80-min period, and their IL, EL, and GL were measured by three different questions (see Questions QIL-QEL-QGL sub-section) regarding each WetlabE application process.

Participants

A total of 105 pre-service teachers participated in the present study. The characteristics of the participants in both experimental groups (EImss-1, EImss-2) and the control group (ASLE) are explained in Table 2.

According to Table 2, in “Experiments of the Participants a” column, all the participants in EImms-2 group and almost all participants in EImms-1 and ASLE groups excelled in the use of computers such as Microsoft Office applications, the Internet, e-mail, inquiry, and searches for academic purposes on the Internet, and they were able to use Facebook and MSN applications for the purpose of socializing on the Internet. In addition to these qualifications, these participants had performed actual laboratory applications at least 11 times before. In this context, they were accepted as experienced pre-service teachers in terms of using computers and actual laboratory applications.

Content of the study

Throughout the study, there were 20 different science experiments that were selected by seven different experts on the content of the Science and Technology Laboratory Applications-II course. When selecting the science experiments, the following considerations were taken into account: (a) difficulty in performing the experiment, (b) experiencing learning disabilities during the science experiments,

Table 2. Characteristics of the participants in EImms-1, EImms-2, and ASLE groups.

Groups	Gender					Age		Experiments of the participants[a]	
	Female		Male		Total	$\bar{x}$	sd	n	f (%)
	n	f (%)	n	f (%)	n				
EImms-1	26	66.6	13	33.3	39	20.46	0.88	37	94.6
EImms-2	24	20.6	10	29.4	34	20.50	1.13	34	100
ASLE	24	75	8	25	32	20.53	0.87	31	96.9

[a] Column shows the numbers and frequencies of the participants regarding their previous experiments on computers and different actual science laboratory applications.

and (c) difficulty in following the experimental processes. The following science experiments are shown in Figure 1.

The structure of the WetlabE and SimbSLE

General structure of WetlabE is based on the science laboratory conditions. Firstly, course lecturer gives brief explanations regarding the aim of the experiment and special concepts as well as the materials which were used by pre-service teachers in the experiment. Secondly, pre-service teachers are familiar with the scientific background of the experiments by means of the experiment sheet. Thirdly, they apply the experiment via instruction steps given in the experiment sheet. In this process, they use experimental apparatus such as power supply, lens, and microscope, connect cables; furthermore, they make observations and take notes related to the experimental results. Having finished the experiment, learners prepare an experiment report.

SimbSLEs were designed according to same instruction steps given for the WetlabE in the experiment sheet for each experiment. The steps are as follows: In the course process applied in computer laboratory, at first, the lecturer gives brief explanations which are the same as the WetlabE. Then, learners read the background of the experiment and execute the SimbSLE program on the computer. They select the experimental apparatus on SimbSLE screen and set the experiment mechanism such as connect cables, arrange power supply etc. via mouse according to the same instruction steps given for the WetlabE on the SimbSLE screen. Moreover, they make observations and take notes during the process. Having finished the experiments, learners prepare an experiment report as in WetlabE condition. The most significant difference between the WetlabE and SimbSLE conditions is that during the WetlabE condition learners use their hands for applying the experiment, whereas in the SimbSLE condition they use mouse, drag-drop, and on click button events for the required arrangements on the computer screen.

Data collection tools

In the present study, a science academic achievement test (SaaT), primary school pre-service teachers' science teaching self-efficacy scale (STSE), an attitude scale toward science teaching scale (AtST), and "Questions Q_{IL}-Q_{EL}-Q_{GL}" were used with the aim of collecting data. The specifications of these data collection tools are explained below.

Science academic achievement test (SaaT)

During the process of developing the SaaT, the views of three different science and technology experts were taken into account with regard to the length, suitability, comprehensibility, and scientific accuracy of the items. The first version of the SaaT used for the pilot study had 52 multiple choice questions related to the 20 different science laboratory experiments. The pilot version of the test was applied to (n=182) pre-service teachers who were successful in the "Science and Technology Laboratory Applications-II" course in the previous year. Subsequently, the test and item analysis were implemented according to data obtained from the pilot study. Moreover, items in which discrimination indexes were less than .25 were removed from the SaaT. The latest version of the SaaT has 37 multiple-choice items. The analysis of the latest version of the SaaT revealed a KR-20 reliability coefficient of .75 and difficulty of .51.

Primary school pre-service teachers' science teaching self-efficacy scale (STSE)

In this study, a primary school pre-service teachers' science teaching self-efficacy scale (STSE) was used. The original scale was developed by Riggs and Enochs (1990). The STSE was adapted into Turkish by Bıkmaz (2002), and its Cronbach's alpha reliability coefficient was determined to be .85. The STSE have has 21 items and two sub-factors that are related to self-efficacy belief and results expectation. Each item includes five choices "strongly agree to strongly disagree." In the present study, the Cronbach's alpha reliability coefficient of STSE was calculated to be .81.

Attitude toward science teaching scale (AtST)

In the present study, an attitude toward science teaching scale (AtST) was used. The AtST was developed by Genç et al. (2010). This scale has 20 items and three sub-categories that are related to subject area (ten items), course lecturer (five items), and individual qualifications of students (five items). Each item includes five choices such as from strongly agree to strongly disagree. The Cronbach's alpha reliability coefficient of AtST was .93, the Kaiser-Meyer-Olkin (KMO) coefficient was .88, and the Bartlett test of significance was .000. In this study, the Cronbach's alpha reliability coefficient of the AtST was determined to be .81.

Questions Q_{IL}-Q_{EL}-Q_{GL}

Under the strength of scientific evidence in the literature, such questions as Q_{IL}-Q_{EL}-Q_{GL} which are similar to those of Opfermann et al. (as cited in Kalyuga, 2009b); Cierniak et al. (2009); and DeLeeuw and Mayer (2008) were used to measure the components of cognitive load.

Q_{IL}, which was used for measuring intrinsic load (IL), is shown below.

Q_{IL}: (a) What degree of difficulty did you experience during the

Table 3. Comparisons (Bonferroni) among the groups.

ANOVA (pre-SaaT)					
Source	**Sum of squares**	**df**	**Mean square**	**F**	**Sig. (p)**
Between groups	61.360	2	30.680	4.612	0.013[a]
Within groups	693.631	102	6.800		
Total	754.990	104			

Multiple comparisons				
Groups	**N**	$\bar{x}$	**sd**	**Bonferroni results (p)**
EImms-1	39	13.05	2.16	0.071[k]
EImss-2	34	11.64	2.74	1.000[l]
ASLE	32	13.46	2.94	0.017[am]

learning process in terms of the complexity of the experiment subject (context)? (b) What degree of difficulty did you experience during the learning process in terms of your prior knowledge regarding the experiment?

$\mathbf{Q_{EL}}$**,** which was used for measuring the extraneous load (EL), is as follows.

$\mathbf{Q_{EL}}$**:** (a) What degree of difficulty did you experience with the learning environment (SimbSLE/WetlabE)? (b) What degree of difficulty did you experience to collect all of the information you need in the learning environment (SimbSLE/WetlabE)?

$\mathbf{Q_{GL}}$**,** which was used for measuring the germane load (GL), is as follows.

$\mathbf{Q_{GL}}$**:** What degree of difficulty did you experience in order to understand the essence meaning of the experiment (learning goals)?

All the questions were answered on a scale from (1) very, very low difficulty to (9) very, very high difficulty.

Structured Interview Form (SiF)

In the SiF, there are eight open-ended questions related to basic variables of the study, including the IL, EL, GL, attitude, self-efficacy, academic achievement, and working environment of the pre-service teachers. During the process of developing the SiF, each question was reviewed by three different experts in terms of its suitability of language, clarity, and relation to the variables. At the end of the first stage, 14 pre-service teachers were assigned randomly for interview. Half of these pre-service teachers were from the ASLE group, and the others were from the EImss-1 and 2 groups. Interviews of the pre-service teachers were performed using the SiF, and the interviews were recorded via video camera. In the next phase, transcripts of video camera records named as ASLE-Student-1 (ASLE-St-1), ASLE-St-2… EImss-St-1, EImss-St-2, etc. were made by the researchers. The transcripts of the student interviews are consisted of 87 pages in total. Two copies were made, one of which was coded by the researcher and the other by an independent PhD candidate. In addition, Miles and Huberman's (1994) inter-coder reliability test was conducted between the researcher's and PhD candidate's codes. The inter-coder reliability of the SiF was determined to be .81.

RESULTS

Here, quantitative and qualitative results of the analysis are given with respect to each research question individually.

Pre-service Teachers' cognitive load types (IL, EL, and GL) are different among the groups in the first stage

The results of ANOVA, descriptive statistics, and multiple comparisons (Scheffe) tests for each experiment among the groups in the first stage are shown in Table 3. As shown in Table 3 (see Appendix A), there was no significant difference between the EImss-1 and EImss-2 groups' average IL scores out of 17 experiments except for experiments 14, 15, and 16; the average EL scores in 18 experiments except for experiments 14 and 15; or the average GL scores in all experiments ($p>0.05^{k}$). However, there were significant differences between the EImss-1 and ASLE groups' average IL scores in 19 experiments, all except experiment 2, and average EL and GL scores in all (20) experiments in favor of EImms-1 ($p<0.05^{al}$). Lastly, there were significant differences between the EImss-2 and ASLE groups' average IL scores in 19 experiments, all except experiment 2, and average EL and GL scores in all experiments in favor of EImms-2 ($p<0.05^{am}$). Due to huge size of Table 3, in this section, it was presented a graph (Figure 2) which shows the results of four experiments such as Exp.-1 Exp.-3, Exp.-11 and Exp.-20.

Pre-service teachers in EImss groups have higher academic achievement

The results of the pre- and post-ANOVA, ANCOVA, and multiple comparisons (Bonferroni) tests among the groups are shown in Table 4.

As shown in Table 4, there were significant differences among the average pre-SaaT scores of the groups ($F_{(2-104)}=4.612$, $p<0.05$) and post-SaaT scores of the groups ($F_{(2-104)}=61.836$, $p<0.001$). Moreover, the post-SaaT Bonferroni test results show that there were significant differences between the EImss-1 and ASLE

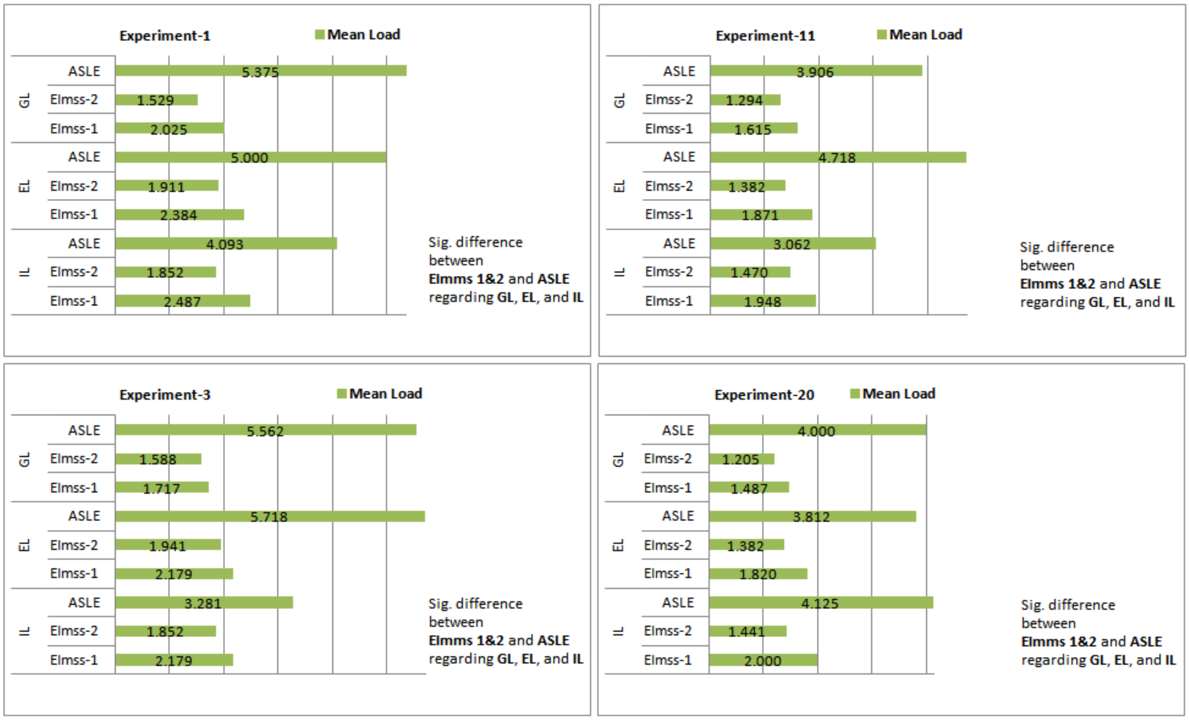

Figure 2. A graph which shows the results of the four experiments.

Table 4. Results of the pre- and post-ANOVA, ANCOVA, and multiple comparisons (Bonferroni) tests.

ANCOVA (post-SaaT)					
Source	**Sum of squares**	**df**	**Mean square**	**F**	**Sig. (p)**
pre-SaaT	178.970	1	178.970	16.844	0.000
Group	1314.052	2	657.026	61.836	0.000[a]
Error	1973.163	101	10.625		
Corrected total	2425.562	104			
Multiple Comparisons					
Groups	**N**	**Meansb**		**Bonferroni results (p)**	
		x̄	**sd**		
Elmms-1	39	27.30	0.52	0.520[k]	
Elmss-2	34	28.37	0.58	0.000[al]	
ASLE	32	20.00	0.58	0.000[am]	

[a] $p < 0.05$; [b] Corrected means; [k]Comparison between Elmss-1 and Elmss-2; [l]Comparison between Elmss-1 and ASLE; [m] Comparison between Elmss-2 and ASLE.

(p=0.000[al]) and between the Elmss-2 and ASLE (p=0.000[am]) in favor of the Elmss-1 and Elmss-2 groups respectively.

Pre-service teachers in Elmss groups have a higher science teaching self-efficacy score

The results of the ANCOVA and multiple comparisons (Bonferroni) tests among the groups are shown in Table 5. As shown in Table 5, there were significant differences among the average post-STSE scores of the groups ($F_{(2\text{-}104)}$=37.980, p<0.001). Moreover, Bonferroni test results show that there were significant differences between the Elmss-1 and ASLE (p=0.000[al]) and the Elmss-2 and ASLE (p=0.000[am]) in favor of the Elmss-1 and Elmss-2 groups respectively.

Pre-service Teachers in Elmss groups have better attitude toward science teaching scores

The results of ANCOVA and multiple comparisons (Bonferroni) tests among the groups are shown in Table 6.

Table 5. Results of the post-STSE ANCOVA and multiple comparisons (Bonferroni) among the groups.

ANCOVA					
Source	**Sum of squares**	**df**	**Mean square**	**F**	**Sig. (p)**
Pre-STSE	1672.469	1	1672.469	77.367	0.000
Group	1642.041	2	821.020	37.980	0.000[a]
Error	2183.359	101	21.617		
Corrected total	4942.914	104			

Multiple Comparisons				
Groups	**N**	**Means[b]**		**Bonferroni results (p)**
		$\bar{x}$	**sd**	
EImms-1	39	81.611	0.746	1.000[k]
EImss-2	34	82.105	0.802	0.000[al]
ASLE	32	73.081	0.834	0.000[am]

[a] p < 0.05; [b] Corrected means; [k]Comparison between EImss-1 and EImss-2; [l]Comparison between EImss-1 and ASLE; [m] Comparison between EImss-2 and ASLE.

Table 6. Results of the post-AtST ANCOVA and multiple comparisons (Bonferroni) among the groups.

ANCOVA					
Source	**Sum of squares**	**df**	**Mean square**	**F**	**Sig. (p)**
Pre-AtST	2025.434	1	2025.434	52.058	0.000
Group	2398.359	2	1199.179	30.821	0.000[a]
Error	3929.641	101	38.907		
Corrected total	8078.133	104			

Multiple comparisons				
Groups	**N**	**$\bar{x}$**	**sd**	**Bonferroni results (p)**
EImms-1	39	86.993	1.016	1.000[k]
EImss-2	34	87.663	1.077	0.000[al]
ASLE	32	76.898	1.107	0.000[am]

[a] p < 0.05 [b] Corrected means [k] Comparison between EImss-1 and EImss-2 [l] Comparison between EImss-1 and ASLE [m] Comparison between EImss-2 and ASLE.

As shown in Table 6, there were significant differences among the average post-AtST scores of the groups ($F_{(2-104)}$=30.821, p<0.001). Moreover, Bonferroni test results show that there were significant differences between the EImss-1 and ASLE (p=0.000[al]) and between the EImss-2 and ASLE (p=0.000[am]) in favor of the EImss-1 and EImss-2 groups respectively.

CL types (IL, EL, and GL) change in both simulation and active laboratory environments

The results of the paired-samples t-tests that were conducted between the measures of CL types (IL, EL, and GL) of the pre-service teachers at the first and the second stage of the research for each experiment are shown in Table 7.

As shown in Table 7 (Appendix B), there were no significant differences between the EImss-1 group's IL scores in the first and the second stage for 16 experiments (apart from experiments 1, 6, 17, and 20), EL scores in 17 experiments (apart from the experiments 1, 2, and 6), or GL scores in 16 experiments (apart from experiments 1, 2, 6, and 20) (p>0.05). In addition to these results, there were no significant differences between the EImss-2 groups' IL scores in the first and second stage in 12 experiments (apart from experiments 1, 2, 6, 7, 8, 14, 16, and 17), EL scores in 12 experiments (apart from experiments 1, 2, 6, 7, 8, 14, 17, and 18), or GL scores in 15 experiments(apart from experiments 1, 2, 6, 13, and 16) (p>0.05).

Lastly, there were significant differences between the ASLE groups' IL, EL, and GL scores in the first and second

Table 7. Results of the post-AtST ANCOVA and multiple comparisons (Bonferroni) among the groups.

ANCOVA					
Source	**Sum of squares**	**df**	**Mean square**	**F**	**Sig. (p)**
Pre-AtST	2025.434	1	2025.434	52.058	0.000
Group	2398.359	2	1199.179	30.821	0.000[a]
Error	3929.641	101	38.907		
Corrected total	8078.133	104			

Multiple Comparisons				
Groups	**N**	**Means[b]**		**Bonferroni results (p)**
		$\bar{x}$	**sd**	
Elmms-1	39	86.993	1.016	1.000[k]
Elmss-2	34	87.663	1.077	0.000[al]
ASLE	32	76.898	1.107	0.000[am]

[a] p < 0.05; [b] Corrected means; [k]Comparison between Elmss-1 and Elmss-2; [l]Comparison between Elmss-1 and ASLE; [m] Comparison between Elmss-2 and ASLE.

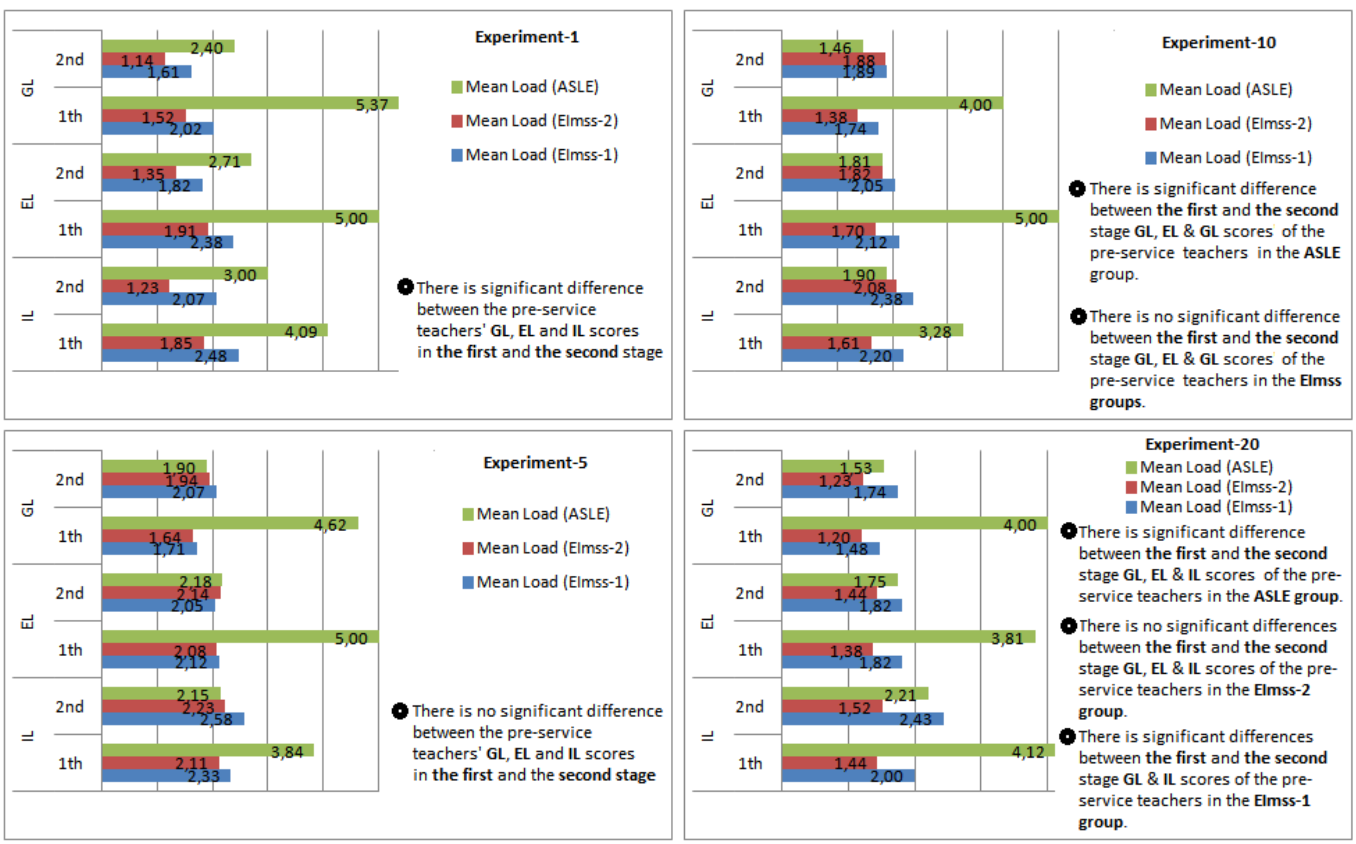

Figure 3. A graph which shows the results of the four experiments.

stages of the research in all the experiments (p<0.05). In the second stage of the research, the pre-service teachers of the ASLE group have less IL, EL, and GL scores than they have the first stage. Due to huge size of Table 7, here, a graph was presented (Figure 3) which shows the results of four experiments such as Exp.-1 Exp.-5, Exp.-10 and

Table 8. Qualitative results of the students' views in EImss groups (themes and codes).

Theme(s)	Code(s)	F
Instructional arrangement	Individualism	4
	Getting attention	4
Effective learning	Obtaining new knowledge	7
	Permanent learning	6
	Meaningful learning	4
Ergonomics	Comfortableness	6
	Appreciation	4
	Enjoyment	4
	Hassle-free	3
	Silence	3
	Lack of computers	2
Breaking prejudice toward science	Decreasing preconceived opinion	7
	Increasing self-efficacy	7
	Positive feelings about science	5
Critical thinking	Causal learning	6
	Asking questions	6

Exp.-20.

Qualitative results of the views of the pre-service teachers in theEImss and the ASLE groups

Here, qualitative results of views of the EImss and ASLE groups are provided.

Qualitative results of the views for the pre-service teachers in the EImss groups

Based on an inductive content analysis of the views of the students in EImss groups, five different themes and 16 different codes were found, which are shown in Table 8. As shown in Table 8, several codes were identified for each theme. Within the instructional arrangement theme, there were two different codes, named "individualism" and "getting attention." In the effective learning theme, there were three different codes, named "obtaining new knowledge," "permanent learning," and "meaningful learning." In the ergonomics theme, there were six different codes, named "comfortableness," "appreciation," "enjoyment," "hassle-free," "silence," and "lack of computers." In the breaking prejudice toward science theme, there were three different codes, named "decreasing preconceived opinions (e.g., …I do not think that the science course is difficult…)," "increasing self-efficacy (e.g., …When I became a teacher, I can teach the science subjects to my students easily…)," and "positive feelings about science (e.g., …I feel that I may be good at science…)." Within the critical thinking theme, there were two different codes, named "causal learning" and "asking questions (e.g., …Now, I am able to ask questions about science subjects…)."

Qualitative results of the views of the pre-service teachers in the ASLE group

Based on the inductive content analysis of the views of the students in the ASLE group, four different themes and 13 different codes were found, which are shown in Table 9.
As shown in Table 9, several codes were determined for each theme. Within the unsuitableness theme, there were four different codes, named "noise," "disturbing the concentration," "light problem," and "small size of working area." In the instructional environment theme, there were two different codes, named "crowdedness" and "unsuitability to work individually." In the self-criticism theme, there were three different codes, named "doing experiment aimlessly," "recognition of needing more work on experiments," and "aware of lack of readiness (e.g., …I understood that I had to learn more science subjects before I did these experiments…)." In the meaning formation theme, there were four different codes, named "difficulty in establishing a relationship among the parts of knowledge (e.g., …I do not know why I did the steps of the experiments, I could not understand all of them…)," "lack

Table 9. Qualitative results of the students' views in ASLE group (themes and codes).

Theme(s)	Code(s)	F
Unsuitableness	Noise	6
	Disturbing the concentration	5
	Light problem	2
	Small size of working area	2
Instructional environment	Crowdedness	5
	Unsuitability to work individually	4
Self-criticism	Doing experiments aimlessly	7
	Recognition of needing more work on experiments	5
	Awareness of lack of readiness	5
Meaning formation	Difficulty in establishing a relationship among the parts of knowledge	7
	Lack of learning the content	5
	Rote learning	4
	Having more learning difficulties	4

of learning the content (e.g., …I could not learn this content because it was too complex and incomprehensible…)," "rote learning," and "having more learning difficulties."

DISCUSSION

In this section, all of the results are discussed together to provide a complete picture and to draw conclusions. According to the latest literature (Ayres, 2006; Backmann, 2010; Cierniak et al., 2009; Paas et al., 2010; Sawicka, 2008; Schnotz and Kürschner, 2007; Whelan, 2007), IL is derived from the inherent complexity of the material or content to be learned. In the present work, the study content was the same for all of the groups, but there were significant differences in IL between the EImss-2 and ASLE groups (p=0.017am, see Table 2). However, at the first stage of the research, both the EImss-1 and EImss-2 groups had a lower average IL score than the ASLE group students for 19 different experiments. Moreover, the results of interviews show that the ergonomics theme was related to six different codes. All of the codes in the theme were positive for the students' learning process except the code "lack of computers." In addition, the results of interviews conducted with the students working in the ASLE group showed that the unsuitableness theme was found in four different codes. Furthermore, all of the codes in this theme were negative for the students' learning process. According to Sweller et al. (1998), presenting information in a logical order and providing the students with capabilities such as the opportunity to zoom in or out as well as providing opportunities to redo experimental stages decreases EL and enhances GL. In addition, multimedia simulations were found to decrease students' IL by providing them with suitable learning environments. In contrast, Hasler et al. (2007) and Paas and Kester (2006) found that IL cannot be manipulated by the instructional environment. Furthermore, van Merrienboer et al. (2006) asserted that the IL of a task depends on one's proficiency in learning the subject. However, in this context, the results of Keramati et al. (2011)'s research support our findings by showing the effect of the organizational readiness factor on students in e-learning environments. In addition, the results of Scheiter et al. (2009) support our findings that learners with more favorable characteristics, such as more positive attitudes, have less cognitive load in a hypermedia environment.

In the first stage of the present research, it was evident that there were significant differences among the students' average EL scores in the EImss and ASLE groups, in favor of the EImss groups, in 17 experiments. In the EImss groups, students used SimbSLE applications to perform the experiments, unlike the ASLE group students, who used WetlabE to perform the experiments. In contrast to Liu and Su's (2011) results, we found that the SimbSLE applications used by the EImss groups were effective in reducing EL, and the latest literature clearly supports our findings (Schnotz and Rasch, 2005; van Merrienboer and Sweller, 2005).

Another important result is related to the students' GL. According to Muller et al. (2008), to provide more cognitive capacity for GL, the EL should be reduced during the learning process, which is an important issue in cognitive load theory. However, the students who worked with SimbSLEs had both low EL and GL in the learning process as opposed to the students in ASLE group. Moreover, our qualitative findings revealed the reason why the students of the EImms groups had both lower EL and GL than students in the ASLE group. The effective learning theme (Table 8) has three different codes (obtaining new knowledge, permanent learning, and meaningful learning), which show students' positive views toward the learning process, whereas the meaning formation theme (see Table 9) has four different codes (difficulty in establishing relationship among the parts of knowledge, lack of learning from the content, rote learning, having more learning difficulties), which shows students' positive views toward the learning process.

Apart from these results, the pre-service teachers' pre- and post-SaaT, STSE, and AtST scores at the end of the first stage of the research in the EImss and ASLE groups are highly significant in providing evidence concerning our claims related to cognitive load. First, we found meaningful differences among the students' post-SaaT scores in favor of the EImss groups. In light of this result, it is clear that the SimbSLE applications used by the EImss groups are more effective than the WetlabE used in the ASLE groups during the learning process. In this context, the latest literature supports our findings (Liu and Su, 2011; Park et al., 2009). Moreover, our qualitative results, such as the effective learning and critical thinking themes obtained from EImms groups and self-criticism and meaning formation themes obtained from ASLE group, explain the effects of the SimbSLE applications on learning. In addition to these results, at the end of the first stage of the research, there were meaningful differences among the pre-service teachers' post-STSE and AtST scores in favor of the EImms groups. Accordingly, we can clearly conclude that the SimbSLE applications increase students' affective characteristics in a positive manner (Cheung et al., 2003; Liu, 2006; Ozmen, 2008). Moreover, we suggest that affective characteristics are effective in learning (Antonietti and Giorgetti, 2006; Kettanurack et al., 2001; Robbins et al., 2004). It was also assumed that SimbSLE applications reduce IL and GL such that if a pre-service teacher works in an ergonomics environment, his/her psychological characteristics, such as intrinsic and extrinsic motivation (Komarraju et al., 2009) and confidence (Stankov et al., 2012), are positively affected. Moreover, pre-service teacher's capability to perform the experiments again and again without any time or experimental equipment pressure is affected in a positive manner. Therefore, a pre-service teacher may use cognitive sources regularly and efficiently. In contrast, pre-service teachers in the ASLE group, who conducted the experiments with WetlabE, may have been negatively affected by the learning environment (see unsuitableness, instructional environments, self-criticism, and meaning formation themes in Table 9). This effect may have led to their increased IL and GL. However, increasing GL alone is not sufficient for improving learning if the learning content or subject is not effectively presented.

Pre-service teachers in the EImss groups completed the first stage with SimbSLE applications and conducted the same experiments with WetlabE in the second stage. The results of the analysis of data obtained from the pre-service teachers in the EImms-1 group in the first and the second stages of the research show that they had statistically equal IL measurements in 16 experiments. In the other four experiments, the students' IL measurements in the second stage were lower than those in the first stage except for Exp-20 ($\bar{x}$Stage-1=2.00; $\bar{x}$Stage-2=2.43). The pre-service teachers' EL measurements were statistically equal in 17 experiments in the first and the second stage. In the other three experiments, the pre-service teachers' EL measurements in the second stage were lower than those of the first stage. In addition, the pre-service teachers' GL measurements were statistically equal in 16 experiments in the first and the second stage. In the other four experiments, the pre-service teachers' EL measurements in the second stage were lower than those of the first stage except for Exp-20 ($\bar{x}$Stage-1=1.48; $\bar{x}$Stage-2=1.74).

According to the results of the data analysis obtained from the pre-service teachers in the EImms-2 group in the first and the second stage of the research, they had statistically equivalent IL measurements in 12 experiments; in the other eight experiments, the pre-service teachers' IL measurements in the second stage were lower than those of the first stage in six experiments except for Exp-14 and Exp-16 (Exp-14: $\bar{x}$Stage-1=1.61, $\bar{x}$Stage-2=2.17; Exp-16: $\bar{x}$Stage-1=1.41, $\bar{x}$ Stage-2=1.88). In terms of EL measurements, pre-service teachers' EL measurements were statistically equivalent in 12 experiments in the first and the second stage. In the other eight experiments, the pre-service teachers' EL measurements in the second stage were lower than the first stage except for Exp-14 ($\bar{x}$ Stage-1=1.64, $\bar{x}$ Stage-2=2.20). In terms of GL measurements, pre-service teachers' GL measurements were statistically equivalent in 15 experiments in the first and the second stage. In the other five experiments, the pre-service teachers' EL measurements in the second stage were lower than the first stage except for Exp-13 and Exp-16 (Exp-13: $\bar{x}$Stage-1=1.23, $\bar{x}$Stage-2=1.76; Exp-16: $\bar{x}$ Stage-1=1.20, $\bar{x}$ Stage-2=1.70). In contrast, the pre-service teachers in the ASLE group in the first and the second stage of the research had significantly lower IL, EL, and GL measurements in all of the experiments in favor of the experiments that were performed in the second stage using SimbSLE applications ($p<0.05$).

It appears that in science teaching courses, SimbSLE-based pre-training applications facilitate students' ability to learn the subjects and to understand natural phenomena according to the relevant scientific rules (Garcia-Luque et al., 2004; Hennessy et al., 2007; Kirschner, 2001; Limniou et al., 2009) by not only using multimedia effects but also by providing an effective and manageable learning environment in which to use their cognitive capacity effectively. In addition, SimbSLE applications support pre-service teachers' affective characteristics such as attitude and self-efficacy, which are important for instruction and learning. However, these characteristics are disregarded in technology-based researches (Leutner, 2014). In this context, Cognitive-Affective Theory of Learning with Media (CATLM) supports the motivational and emotional characteristics of the learners; furthermore, it claims that motivational characteristics of learners affect cognitive engagement by either increasing or decreasing it (Gottfried, 1990; Moreno et al., 2001). Under the strength of our findings related to IL, EL, and GL in the second stage as well as the findings regarding the students' attitude and self-efficacy scores at the end of the first stage, it is evident that learners' affective characteristics and motivational aspects affect learners' cognitive load by decreasing and balancing it. Moreover, the learners' views favor the idea. Findings related to the present study are in parallel with the CATLM characteristics and the results of the latest literature (Mayer, 2014; Park et al., 2014).

According to Lee et al. (2006), in a multimedia learning environment, intrinsic and extraneous cognitive load can be manipulated regarding learners' prior knowledge moderates the effectiveness of these load manipulations. On the other hand, Park et al. (2015) state that emotional and motivational aspects used in the design of multimedia learning material can stimulate emotions and motivation positively so that these affective positive characteristics may facilitate cognitive processing and learning. Moreover, germane load is partly related to learners' motivation (Whelan, 2007). As stated by Park et al. (2015) Cognitive-Affective Theory of Learning with Media (CATLM) reveals a new assumption as 'affective mediation'. According to this assumption, motivational factors can mediate learning by increasing or decreasing cognitive engagement (p.269). Based on these explanations, it is though those dramatic decreases of the pre-service teachers' GL in the second stage of the research are probably related to their affective and motivational characteristics.

Conclusion

During the learning process, if the learning content is too abstract, the skills are too complex to learn, or learners are injured or equipment damaged during the first attempt, simulations should be used. Moreover, after learners have had the first experience via simulation, such as in the case of scientific experiments or a pilot training process, they can generally perform real applications quite successfully or can learn the procedures more efficiently. The key question, "How successful are students after they used simulations?" has been described in the literature (see Pavio's Dual Coding Theory, Mayer's Multimedia Learning Theory, and Cognitive Load Theory – van Merrienboer, Sweller et al.). From the perspective of cognitive load theory, multimedia simulations can reduce EL, which is unnecessary for learning, and therefore provide more cognitive resources for GL, which is important for learning. We agree with these findings, and we also claim that pre-training applications applied by explanatory simulations not only support learners' willingness but also help them to arrange their cognitive resources by affecting their affective characteristics such as self-efficacy and attitude in a positive manner, thus potentially reducing their IL and GL.

In addition, our findings may open a new line of research regarding the one of the vital issue, "Are cognitive load effects affected by students' motivation?" posited by Brünken et al. (2010, p.262). For instance, there are two learners who want to learn the same topic as well as having the same characteristics regardless of motivation. While one of them has high motivational characteristics such as attitude and self-efficacy, the other one has low ones. The vital question is which learner is exposed to high cognitive load in the learning process. Inherently, the learners having high motivational characteristics are supposed to report that he/she has exposed to less difficulty during the learning process while those having low motivational characteristics state that s/he has exposed to much more difficulty. Despite the fact that learners have the same cognitive structure, why have they exposed to different amount of cognitive load? In this context, our research clarifies the reasons for these differences between the amounts of learners' cognitive load with regard to their affective characteristics. Therefore, the theoretical structure of CLT may be modified by conducting deeper research focused on motivational factors such as self-efficacy and attitude. Moreover, the detailed observations enabled by explanatory simulations affect students' motivation, therefore potentially moderating the IL. As a consequence of this study, in future research, the theoretical structure of CLT should be modified by using the structural equation model analysis technique in terms of the affective characteristics of learners.

Limitations of the study

There are two main limitations in the present study. The first one is that there are different measurement tools and techniques in the literature to determine the measure of cognitive load such as fMRI, heart rate, eye tracking etc. Self-report measurement tool was used in the study. The second one is the science experiments applied in the study did not have a complicated structure such as pilot simulation etc.

Conflict of Interests

The author has not declared any conflicts of interest.

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Appendix A.

Table 3. Results of ANOVA and descriptive statistics among the pre-service teachers in the EImms-1, EImms-2, and the ASLE groups in terms of IL, EL, and GL measurements in the first stage.

Cognitive load	Groups[n]	Experiment 1 ANOVA	Experiment 1 Multiple comparisons (Scheffe)		Experiment 2 ANOVA	Experiment 2 Multiple comparisons (Scheffe)		Experiment 3 ANOVA	Experiment 3 Multiple comparisons (Scheffe)		Experiment 4 ANOVA	Experiment 4 Multiple comparisons (Scheffe)	
		p	$\bar{x}$	p	p	$\bar{x}$	p	p	$\bar{x}$	p	p	$\bar{x}$	p
	EImss-1		2.487	0.070^{k}		2.564	0.984^{k}		2.179	0.554^{k}		2.051	0.114^{k}
IL	EImss-2	0.000^{a}	1.852	0.002^{al}	0.186	2.500	0.333^{l}	0.000^{a}	1.852	0.002^{al}	0.000^{a}	1.470	0.000^{al}
	ASLE		4.093	0.000^{am}		3.125	0.250^{m}		3.281	0.000^{am}		3.843	0.000^{am}
	EImss-1		2.384	0.237^{k}		2.307	0.843^{k}		2.179	0.702^{k}		2.179	0.123^{k}
EL	EImss-2	0.000^{a}	1.911	0.000^{al}	0.000^{a}	2.147	0.000^{al}	0.000^{a}	1.941	0.000^{al}	0.000^{a}	1.500	0.000^{al}
	ASLE		5.000	0.000^{am}		6.218	0.000^{am}		5.718	0.000^{am}		4.875	0.000^{am}
	EImss-1		2.025	0.199^{k}		2.205	0.720^{k}		1.717	0.899^{k}		1.641	0.503^{k}
GL	EImss-2	0.000^{a}	1.529	0.000^{al}	0.000^{a}	1.970	0.000^{al}	0.000^{a}	1.588	0.000^{al}	0.000^{a}	1.294	0.000^{al}
	ASLE		5.375	0.000^{am}		5.781	0.000^{am}		5.562	0.000^{am}		4.343	0.000^{am}
			Experiment-5			Experiment-6			Experiment-7			Experiment-8	
	EImss-1		2.333	0.788^{k}		3.846	0.160^{k}		2.743	0.626^{k}		3.153	0.840^{k}
IL	EImss-2	0.000^{a}	2.117	0.000^{al}	0.000^{a}	3.235	0.002^{al}	0.000^{a}	3.000	0.000^{al}	0.004^{a}	2.941	0.026^{al}
	ASLE		3.843	0.000^{am}		5.000	0.000^{am}		4.156	0.000^{am}		4.156	0.007^{am}
	EImss-1		2.128	0.992^{k}		3.435	0.895^{k}		2.384	0.034^{k}		2.794	0.922^{k}
EL	EImss-2	0.000^{a}	2.088	0.000^{al}	0.000^{a}	3.294	0.000^{al}	0.000^{a}	3.029	0.000^{al}	0.000^{a}	2.741	0.000^{al}
	ASLE		5.000	0.000^{am}		6.125	0.000^{am}		5.156	0.000^{am}		5.093	0.000^{am}
	EImss-1		1.717	0.962^{k}		3.076	0.184^{k}		2.076	0.998^{k}		2.435	0.970^{k}
GL	EImss-2	0.000^{a}	1.647	0.000^{al}	0.000^{a}	2.500	0.000^{al}	0.000^{a}	2.058	0.000^{al}	0.000^{a}	2.352	0.000^{al}
	ASLE		4.625	0.000^{am}		5.937	0.000^{am}		4.875	0.000^{am}		5.093	0.000^{am}
			Experiment-9			Experiment-10			Experiment-11			Experiment-12	
	EImss-1		2.923	0.127^{k}		2.205	0.085^{k}		1.948	0.147^{k}		2.435	0.113^{k}
IL	EImss-2	0.000^{a}	2.205	0.007^{al}	0.000^{a}	1.617	0.001^{al}	0.000^{a}	1.470	0.000^{al}	0.000^{a}	1.882	0.008^{al}
	ASLE		4.062	0.000^{am}		3.281	0.000^{am}		3.062	0.000^{am}		3.281	0.000^{am}
	EImss-1		2.871	0.180^{k}		2.128	0.267^{k}		1.871	0.235^{k}		2.230	0.478^{k}
EL	EImss-2	0.000^{a}	2.235	0.000^{al}	0.000^{a}	1.705	0.000^{al}	0.000^{a}	1.382	0.000^{al}	0.000^{a}	1.882	0.000^{al}
	ASLE		5.187	0.000^{am}		5.000	0.000^{am}		4.718	0.000^{am}		4.687	0.000^{am}
	EImss-1		2.435	0.327^{k}		1.745	0.335^{k}		1.615	0.374^{k}		1.846	0.673^{k}
GL	EImss-2	0.000^{a}	1.941	0.000^{al}	0.000^{a}	1.342	0.000^{al}	0.000^{a}	1.294	0.000^{al}	0.000^{a}	1.588	0.000^{al}
	ASLE		4.687	0.000^{am}		4.000	0.000^{am}		3.906	0.000^{am}		4.375	0.000^{am}

[n] Shows the number of the pre-service teachers in the groups EImss-1=39, EImss-2=34, and ASLE=32 respectively. [a] $p < 0.05$; [k] Comparison between EImss-1 and EImss-2; [l] Comparison between EImss-1 and ASLE; [m] Comparison between EImss-2 and ASLE.

Table 3. continues…

		Experiment-13			Experiment-14			Experiment-15			Experiment-16		
Cognitive Load	**Groups[n]**	**ANOVA**	**Multiple comparisons (Scheffe)**		**ANOVA**	**Multiple comparisons (Scheffe)**		**ANOVA**	**Multiple comparisons (Scheffe)**		**ANOVA**	**Multiple Comparisons (Scheffe)**	
		p	$\bar{x}$	**p**	**p**	$\bar{x}$	**p**	**p**	$\bar{x}$	**p**	**p**	$\bar{x}$	**p**
	EImss-1		2.128	0.318[k]		2.871	0.000[ak]		2.692	0.012[ak]		2.307	0.014[ak]
IL	EImss-2	0.000[a]	1.647	0.000[al]	0.000[a]	1.617	0.000[al]	0.000[a]	1.823	0.000[al]	0.000[a]	1.411	0.000[al]
	ASLE		4.031	0.000[am]		4.218	0.000[am]		3.906	0.000[am]		4.000	0.000[am]
	EImss-1		2.128	0.230[k]		2.589	0.010[ak]		2.384	0.049[ak]		2.076	0.069[k]
EL	EImss-2	0.000[a]	1.529	0.000[al]	0.000[a]	1.647	0.000[al]	0.000[a]	1.676	0.000[al]	0.000[a]	1.441	0.000[al]
	ASLE		4.843	0.000[am]		5.062	0.000[am]		4.906	0.000[am]		4.343	0.000[am]
	EImss-1		1.692	0.365[k]		2.230	0.108[k]		2.025	0.177[k]		1.820	0.166[k]
GL	EImss-2	0.000[a]	1.235	0.000[al]	0.000[a]	1.529	0.000[al]	0.000[a]	1.470	0.000[al]	0.000[a]	1.205	0.000[al]
	ASLE		3.875	0.000[am]		4.343	0.000[am]		4.281	0.000[am]		3.750	0.000[am]
		Experiment-17			Experiment-18			Experiment-19			Experiment-20		
	EImss-1		2.948	0.036[k]		2.410	0.089[k]		2.205	0.266[k]		2.000	0.195[k]
IL	EImss-2	0.000[a]	2.029	0.012[al]	0.000[a]	1.705	0.000[al]	0.000[a]	1.647	0.000[al]	0.000[a]	1.441	0.000[al]
	ASLE		4.031	0.000[am]		3.781	0.000[am]		4.093	0.000[am]		4.125	0.000[am]
	EImss-1		2.384	0.173[k]		2.307	0.130[k]		1.923	0.604[k]		1.820	0.352[k]
EL	EImss-2	0.000[a]	1.794	0.000[al]	0.000[a]	1.676	0.000[al]	0.000[a]	1.588	0.000[al]	0.000[a]	1.382	0.000[al]
	ASLE		5.062	0.000[am]		5.125	0.000[am]		4.593	0.000[am]		3.812	0.000[am]
	EImss-1		2.410	0.121[k]		1.846	0.195[k]		1.641	0.749[k]		1.487	0.680[k]
GL	EImss-2	0.000[a]	1.735	0.000[al]	0.000[a]	1.352	0.000[al]	0.000[a]	1.382	0.000[al]	0.000[a]	1.205	0.000[al]
	ASLE		4.562	0.000[am]		4.312	0.000[am]		4.093	0.000[am]		4.000	0.000[am]

[n] Shows the number of the pre-service teachers in the groups EImss-1=39, EImss-2=34, and ASLE=32 respectively. [a] $p < 0.05$; [k] Comparison between EImss-1 and EImss-2; [l] Comparison between EImss-1 and ASLE; [m] Comparison between EImss-2 and ASLE.

Appendix B.

Table 7. Paired samples T-test results for IL, EL and GL in the 1th and the 2nd stages of the research.

	Load types	Stages	Elmss-1			Elmss-2			ASLE		
			$\bar{x}$	t	p	$\bar{x}$	t	p	$\bar{x}$	t	p
Exp.-1	IL	1th 2nd	2.48 2.07	2.45	0.000[a]	1.85 1.23	3.56	0.001[a]	4.09 3.00	2.90	0.007[a]
	EL	1th 2nd	2.38 1.82	2.91	0.006[a]	1.91 1.35	3.28	0.002[a]	5.00 2.71	6.15	0.000[a]
	GL	1th 2nd	2.02 1.61	2.08	0.044[a]	1.52 1.14	2.72	0.010[a]	5.37 2.40	6.40	0.000[a]
Exp.-2	IL	1th 2nd	2.56 2.35	1.05	0.299	2.50 1.26	4.17	0.000[a]	3.12 2.37	2.43	0.021[a]
	EL	1th 2nd	2.30 1.89	2.20	0.034[a]	2.14 1.26	3.40	0.002[a]	6.21 2.12	14.17	0.000[a]
	GL	1th 2nd	2.20 1.69	2.47	0.018[a]	1.97 1.11	3.40	0.002[a]	5.78 1.87	13.52	0.000[a]
Exp.-3	IL	1th 2nd	2.17 2.33	-0.703	0.487	1.85 1.41	1.96	0.058	3.28 2.18	3.11	0.004[a]
	EL	1th 2nd	2.17 2.17	0.000	1.000	1.94 1.47	1.93	0.062	5.71 2.21	13.56	0.000[a]
	GL	1th 2nd	1.71 2.05	-1.80	0.079	1.58 1.29	1.82	0.077	5.56 1.87	11.03	0.000[a]
Exp.-4	IL	1th 2nd	2.05 2.43	-1.95	0.058	1.47 1.88	-1.87	0.070	3.84 2.00	5.05	0.000[a]
	EL	1th 2nd	2.17 2.00	0.73	0.465	1.50 1.82	-1.34	0.190	4.87 1.78	7.50	0.000[a]
	GL	1th 2nd	1.64 1.87	-1.29	0.202	1.29 1.70	-2.02	0.051	4.34 2.84	3.85	0.001[a]
Exp.-5	IL	1th 2nd	2.33 2.58	-1.20	0.237	2.11 2.23	-0.44	0.656	3.84 2.15	4.13	0.000[a]
	EL	1th 2nd	2.12 2.05	0.35	0.727	2.08 2.14	-0.20	0.842	5.00 2.18	6.69	0.000[a]
	GL	1th 2nd	1.71 2.07	-1.55	0.128	1.64 1.94	-1.18	0.244	4.62 1.90	7.17	0.000[a]
Exp.-6	IL	1th 2nd	3.84 2.66	5.77	0.000[a]	3.23 1.88	4.53	0.000[a]	5.00 3.31	4.41	0.000[a]

Table 7. Cont'd

	EL	1^{th}	3.43	4.64	0.000[a]	3.29	5.64	0.000[a]	6.12	9.19	0.000[a]
		2^{nd}	2.25			1.67			2.90		
	GL	1^{th}	3.07	2.09	0.043[a]	2.50	2.77	0.009[a]	5.93	8.71	0.000[a]
		2^{nd}	2.41			1.67			2.71		
	IL	1^{th}	2.75	-1.16	0.253	3.00	4.34	0.000[a]	4.15	5.03	0.000[a]
		2^{nd}	3.04			2.20			2.53		
Exp.-7	EL	1^{th}	2.38	-0.829	0.412	3.02	4.65	0.000[a]	5.15	7.80	0.000[a]
		2^{nd}	2.61			2.08			2.34		
	GL	1^{th}	2.07	-1.43	0.161	2.05	0.29	0.773	4.87	7.71	0.000[a]
		2^{nd}	2.51			2.00			1.90		
	IL	1^{th}	3.15	1.41	0.165	2.94	2.95	0.006[a]	4.15	3.67	0.001[a]
		2^{nd}	2.76			2.02			2.87		
Exp.-8	EL	1^{th}	2.79	0.53	0.597	2.94	3.44	0.002[a]	5.09	6.98	0.000[a]
		2^{nd}	2.65			1.76			2.37		
	GL	1^{th}	2.43	-0.18	0.857	2.35	1.84	0.074	5.09	7.66	0.000[a]
		2^{nd}	2.48			1.82			2.15		
	IL	1^{th}	2.92	0.498	0.622	2.20	0.469	0.642	4.06	4.82	0.000[a]
		2^{nd}	2.79			2.05			2.28		
Exp.-9	EL	1^{th}	2.87	1.34	0.185	2.23	1.01	0.316	5.18	7.71	0.000[a]
		2^{nd}	2.51			1.91			2.18		
	GL	1^{th}	2.43	0.19	0.846	1.94	0.47	0.636	4.68	9.40	0.000[a]
		2^{nd}	2.38			1.79			1.78		
	IL	1^{th}	2.20	-1.19	0.242	1.61	-1.96	0.580	3.28	5.71	0.000[a]
		2^{nd}	2.38			2.08			1.90		
Exp.-10	EL	1^{th}	2.12	0.40	0.691	1.70	-0.44	0.657	5.00	12.27	0.000[a]
		2^{nd}	2.05			1.82			1.81		
	GL	1^{th}	1.74	-0.79	0.430	1.38	-2.02	0.051	4.00	11.05	0.000[a]
		2^{nd}	1.89			1.88			1.46		

[a] $p < 0.05$. [p]Participants (EImss-1=39; EImss-2=34; ASLE=32).

Table 7. Continued…

	Load Types	Stages	Elmss-1			Elmss-2			ASLE		
			$\bar{x}$	t	p	$\bar{x}$	t	p	$\bar{x}$	t	p
Exp.-11	IL	1th	1.94	-1.49	0.142	1.47	-0.54	0.587	2.75	6.58	0.000[a]
		2nd	2.20			1.58			1.50		
	EL	1th	1.87	0.92	0.360	1.38	-0.86	0.394	4.71	9.57	0.000[a]
		2nd	1.74			1.55			1.43		
	GL	1th	1.61	-1.83	0.075	1.26	-1.39	0.173	3.90	8.70	0.000[a]
		2nd	2.00			1.52			1.37		
Exp.-12	IL	1th	2.43	1.46	0.151	1.88	0.00	1.000	3.28	4.85	0.000[a]
		2nd	2.17			1.88			2.12		
	EL	1th	2.23	1.31	0.198	1.88	0.23	0.815	4.68	9.777	0.000[a]
		2nd	2.02			1.82			2.03		
	GL	1th	1.84	0.29	0.767	1.58	-5.59	0.555	4.37	7.49	0.000[a]
		2nd	1.79			1.73			1.65		
Exp.-13	IL	1th	2.12	-1.99	0.054	1.64	-0.74	0.464	4.03	5.68	0.000[a]
		2nd	2.51			1.79			2.28		
	EL	1th	2.12	0.81	0.421	1.52	-0.68	0.500	4.84	7.45	0.000[a]
		2nd	1.92			1.67			2.00		
	GL	1th	1.69	-0.35	0.727	1.23	-2.65	0.012[a]	3.87	6.26	0.000[a]
		2nd	1.76			1.76			1.78		
Exp.-14	IL	1th	2.87	0.25	0.800	1.61	-2.23	0.033[a]	4.21	7.32	0.000[a]
		2nd	2.82			2.17			2.21		
	EL	1th	2.58	0.46	0.643	1.64	-2.03	0.050[a]	5.06	9.71	0.000[a]
		2nd	2.48			2.20			1.87		
	GL	1th	2.23	-0.99	0.328	1.52	-1.50	0.141	4.34	6.75	0.000[a]
		2nd	2.48			1.91			1.68		
Exp.-15	IL	1th	2.69	1.24	0.221	1.82	-0.12	0.900	3.90	6.10	0.000[a]
		2nd	2.46			1.85			1.96		
	EL	1th	2.38	1.63	0.110	1.67	-0.52	0.600	4.90	8.64	0.000[a]
		2nd	2.07			1.79			1.93		
	GL	1th	2.02	0.35	0.723	1.47	-0.96	0.339	4.28	9.09	0.000[a]
		2nd	2.94			1.70			1.46		
Exp.-16	IL	1th	2.30	-0.52	0.606	1.41	-2.76	0.009[a]	4.00	6.29	0.000[a]
		2nd	2.41			1.88			2.03		
	EL	1th	2.07	-0.25	0.803	1.44	-2.02	0.051	4.34	9.04	0.000[a]
		2nd	2.12			1.85			2.03		

Table 7. Cont'd

	GL	1th	1.82	-0.38	0.701	1.20	-2.31	0.027[a]	3.75	5.90	0.000[a]
		2nd	1.89			1.70			1.50		
	IL	1th	2.94	2.69	0.010[a]	2.02	2.24	0.032[a]	4.03	2.34	0.026[a]
		2nd	2.33			1.67			3.12		
Exp.-17	EL	1th	2.38	1.51	0.139	1.79	2.41	0.021[a]	5.06	7.34	0.000[a]
		2nd	1.97			1.41			2.59		
	GL	1th	2.41	0.16	0.866	1.73	1.89	0.067	4.56	4.70	0.000[a]
		2nd	2.35			1.44			2.68		
	IL	1th	2.41	0.26	0.793	1.70	1.87	0.070	3.78	3.78	0.001[a]
		2nd	2.35			1.35			2.43		
Exp.-18	EL	1th	2.30	0.96	0.343	1.67	2.41	0.021[a]	5.12	7.98	0.000[a]
		2nd	2.12			1.29			2.15		
	GL	1th	1.84	-0.56	0.578	1.35	0.96	0.343	4.31	6.76	0.000[a]
		2nd	1.94			1.20			1.96		
	IL	1th	2.20	-0.62	0.534	1.64	0.95	0.347	4.09	5.63	0.000[a]
		2nd	2.30			1.41			2.12		
Exp.-19	EL	1th	1.92	-0.55	0.584	1.58	0.46	0.649	4.59	6.94	0.000[a]
		2nd	2.00			1.47			1.93		
	GL	1th	1.64	-0.42	0.674	1.38	0.90	0.370	4.09	6.87	0.000[a]
		2nd	1.71			1.17			1.62		
	IL	1th	2.00	-2.54	0.015[a]	1.44	-0.62	0.540	4.12	5.55	0.000[a]
		2nd	2.43			1.52			2.21		
Exp.-20	EL	1th	1.82	0.00	1.000	1.38	-0.42	0.676	3.81	5.83	0.000[a]
		2nd	1.82			1.44			1.75		
	GL	1th	1.48	-2.03	0.048[a]	1.20	-0.23	0.812	4.00	6.52	0.000[a]
		2nd	1.74			1.23			1.53		

[a] $p < 0.05$; [n]Participants (EImss-1=39; EImss-2=34; ASLE=32).