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Scaffolding prompt questions and learners' self-regulated learning about the nature of science in hypermedia

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Abstract

This study aimed to investigate the impact of scaffolding prompt questions on learners' self-regulated learning about the Nature of Science (NOS) in a hypermedia environment. In this study, mixed methods research design was employed. Sixty-four pre-service science teachers (n=64) were randomly assigned to the experimental group (N:33, scaffolding for self-regulation) and the control group (N:31, no scaffolding for self-regulation). Both groups were trained on how to use hypermedia while learning about NOS. Participants in the experimental group were scaffolded regarding how to regulate learning with hypermedia, whereas participants in the control were not given any instruction about self-regulation. MSLQ and think-aloud protocols were used to measure participants' self-regulation behaviors. Also, we collected data via VOSTS questionnaire to identify any changes in participants' understandings about NOS from pre-test to post-test. The findings that emerged from MSLQ showed that the experimental group performed better self-regulation behaviors than the control group. Also, it was found that participants in the experimental group used several effective self-regulated behaviors which seemed to foster their learning. By contrast, participants in the control group were not effective at regulating their learning. According to the control group, the analyses of post-tests of VOSTS indicate that the experimental group achieved a more informed understanding of NOS. Implications for enhancing our understandings of how learners self-regulate their learning process and what assistance they need are presented.

Keywords: Self-regulation; hypermedia; scaffolding; nature of science; computer-based learning

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1. Introduction

1.1. Introduce the problem

Recently, rapid technological advances have made the world smaller by causing people and societies to become closer to each other (Şeker Bektaş, 2005). These technologies have changed the way to access information. With the internet's help, getting information from all over the world in the desired location and time has become very fast and almost effortless. Hence, the role and importance of computer-based learning in education have increased. In general, computer-based learning environments (CBLE) have the potential to foster learning by presenting opportunities to the learner (Lajoie & Azevedo, 2006). The term 'hypermedia' is a particular use of CBLE and it refers to using a wide range of forms of information, including text, graphs, sound, and video (Jacobson & Archodidou, 2000). Moreover, hypermedia is a powerful learning tool utilized to foster students' learning (Azevedo & Cromley, 2004). This learning environment gives learners an opportunity to have free navigation by presenting information in a non-linear format (Lawless & Brown, 1997; Zumbach, Ortler, Deibl, & Moser, 2020) and many learners are not good at learning in such a learning environment (Lajoie & Azevedo 2006). One reason is that learners do not know how to use this technology effectively due to its complex and non-linear structure. Since such learning environments display open-ended features, the learner must control and regulate the learning process (Azevedo, 2005). The other reason is that learning in hypermedia occurs individually. So, the use of such a learning environment requires maximum learner control in their learning (Santhanam, Sasidharan, & Webster, 2008). Likewise, learners need to manage their own learning in hypermedia, which means setting learning goals, monitoring, and adapting learning strategies (Williams, 1996; Winne & Perry, 2000). Students need to become aware of their learning experiences for constructing knowledge (Menekse, Stump, Krause, & Chi, 2013). If students can not regulate their learning processes in hypermedia, such a learning environment result in little learning (Greene & Land, 2000). Thus, self-regulation can be seen as the best predictor of successful learning in such learning environments.

1.2. Why Self-Regulated Learning is Crucial for Hypermedia?

Categorically hypermedia is a type of CBLE. It is a powerful learning tool that presents information (content) as text, graphics, animation, sound, and video in a non-linear order (Scheiter & Gerjets, 2007). Students positioned in the center of hypermedia (Jonassen & Reeves, 1996). In other words, hypermedia is a computer-based information access system where users can freely navigate and have links (bridges) between pieces of information. Hypermedia provides users the ability to switch to different information and screens on the subject through hyperlinks without reading a linear path in the reading

texts as in the book (McKnight, Dillon, & Richardson, 1996). Hence , necessitating learners to select the information they need among a pile of information (Greene, Bolick, & Robertson, 2010). Hypermedia is defined as learner-controlled education because it allows the learner to navigate freely (Williams, 1996). It is a powerful tool that facilitates learning complex topics (Azevedo & Cromley, 2004). Since the presentation of information in the same system with more than one source increases the potential power of hypermedia in education. However, despite this educational potential power of hypermedia, studies have revealed that there are some problems in the effectiveness and efficiency of learning in this learning environment (Lajoie & Azevedo, 2006). This is due to the nature of the hypermedia as dynamic, non-linear, and arbitrary elements, and it is explained as many students have not enough skills to use this environment (Dillon & Gabbard, 1998; Shapiro & Niederhauser, 2004). Students do not know how to choose and manipulate the required information based on their planning, goals, prior knowledge, motivation, and self-knowledge, and beliefs among the information presented them as multiple representations (Winters, Greene, & Costich, 2008). Because of all these reasons, self-regulation can be seen as a key to uncovering the power of hypermedia, and it is a response to the most critical question in learning within it that how a learner can regulate his/her learning for effective learning in hypermedia (Azevedo, Guthrie, &Seibert, 2004).

Self-regulation is based on Albert Bandura's (1986) social cognition theory, which suggests that all activities and behaviors of human beings are subject to environmental, personal, and behavioral factors that go outside their own will. Zimmerman (2002) discusses self-regulation in terms of learning and defines self-regulation to understand how and why students manage their learning in education. According to Zimmerman (1989), self-regulated students can use metacognitive strategies in learning and they are motivated to learn. Also, they can self-monitor, self-feedback, self-evaluation while learning that based on their goals. Self-regulation refers to organizing one's learning, including time and information (Cheng, 2011). Pintrich (2000, p.453) defined self-regulation as "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features in the environment." Therefore, self-regulated learners control their learning processes in many ways (Winne & Perry, 2000). For instance, students determine and plan learning objectives at the beginning of learning, and then they follow learning processes and learning outcomes with metacognitive skills. Furthermore, self-regulation leads learners to feel good in the learning process as it gives the learners the freedom to choose the learning strategy they achieve (Pintrich, 2000).

Students' self-regulation while learning in hypermedia means to be aware of how to learn, how much they will learn, how much time they will spend, what plans and strategies they will use to learn. For instance, a self-regulated learner in such a learning

environment knows to select information sources according to learning goals (Schnotz, 1998). Hence, in recent years, researchers have begun to examine the effects of self-regulation in learning difficult subjects in hypermedia (Greene, Bolick, & Robertson, 2010). Some studies investigate the role of SRL within CBLE. The findings indicate that self-regulation positively impacts effective learning in CBLE (Cai, Wang, Xu, & Zhou, 2020; Dent & Koenka, 2016; Müller & Seufert, 2018; Santhanam, Sasidharan, & Webster, 2008). But these findings might imply that self-regulation could be effective in learning when students have self-regulation behaviors. Thus, learners should be scaffolded to show these self-regulated behaviors, since self-regulation is not an innate ability. Numerous studies have pointed out that scaffolding is crucial in fostering students' learning (e.g. Chi et al., 2001). Without scaffolding, students may not regulate their learning, causing them to perform low performance (Azevedo & Cromley, 2004). As self-regulation is seen as an essential component for success in a computer-based learning environment (Lajoie & Azevedo, 2006), using prompts or hints as scaffolds leads to increased students' learning performance (Müller & Seufert,2018). Scaffolding students through self-regulation prompts in CBLE is an efficient strategy to reveal students' self-regulation behaviors (Wong et al., 2019). The effect of scaffolding on the association between self-regulation and high learning performance in hypermedia was indicated in a large body of previous studies (Azevedo & Hadwin, 2005; Bannert et al., 2015; Delen, Liew & Wilson, 2014; Lawrie et al., 2016; Müller & Seufert, 2018; Sitzmann, Bell, Kraiger & Kanar, 2009; Wong et al., 2019). Based on these studies' findings, we predicted that the scaffolding leads participants to perform better self-regulated learning compared to the other group who had received no scaffolding.

Many studies conducted on SRL and hypermedia have been conducted in several disciplines such as science (Azevedo & Crombley, 2004), mathematics (Kramarski & Gutman, 2006), and psychology (Winters, Greene & Costich, 2008). But there is no research in Nature of Science (NOS) learning. NOS is challenging and difficult issues for both students and teachers, whereas it is a necessary component of scientific literacy (Abd-El-Khalick & Lederman, 2000). While NOS's value in science education has been appreciated, nowadays, there is a consensus among scientists that an adequate understanding of NOS should be developed in science teaching. Despite this consensus, it was found that science teachers were mostly oblivious to have a sufficient understanding of the NOS. Therefore, a new research topic among scientists is to develop teachers' understanding of NOS.

1.3. The Present Study and Research Questions

In this study, we examined how scaffolding prompt questions affected pre-service science teachers' self-regulation behaviors and their conceptual understandings of NOS in hypermedia.

This study focused on the following research questions:

- Do "Scaffolding Prompt Questions" make an impact on pre-service science teachers' self-regulation behaviors?
- What types of self-regulation behaviors do participants exhibit when learning about the NOS within hypermedia?
- What is the effect of self-regulation on pre-service science teachers' understandings of the NOS in hypermedia?

2. Method

2.1. Participants

The participants of the study included 64 pre-service science teachers were randomly assigned to either control group or experimental group. The first group (control group) included 31 junior pre-service science teachers, and the second group (experimental group) included 33 junior pre-service science teachers. There were 5 male and 28 female participants in the experimental group, and 8 male and 23 female participants in the control group. The participants of both groups were enrolled in the Department of Elementary Science in the college of Education in Ankara, Turkey.

2.2. Experimental Design

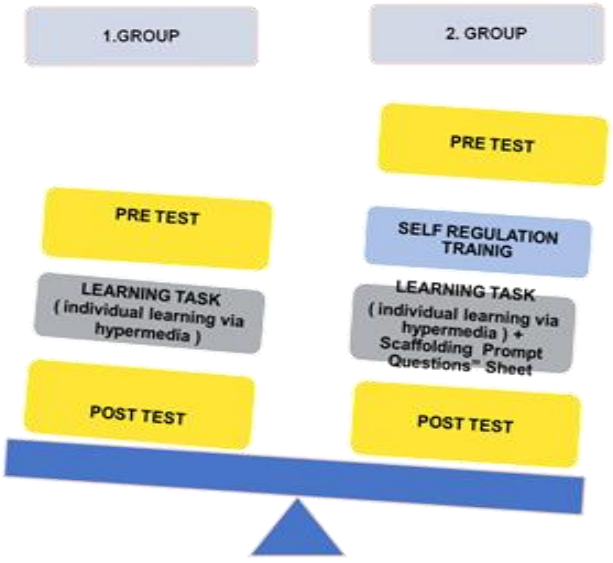

Figure 1. Schematic representation of the research design followed in the study

2.3. Measures

2.3.1. Motivated strategies for learning questionnaire

An adapted Turkish version of the Motivated Strategies for Learning Questionnaire (MSLQ) developed by Büyüköztürk et al. (2004) was used to reveal the self-regulation behaviors of pre-service science teachers before and after instruction. The MSLQ is an 81-item self-report questionnaire that measures the self-regulation strategies and motivational beliefs of learners. It is composed of two subscales; the Motivation subscale includes six factors, and the Learning strategy subscale consists of nine factors. In total, the scale has fifteen factors. The Cronbach alpha of the subscales ranged from 0.56 to 0.81 for the items.

2.3.2. Views on science-technology-society (VOSTS) instrument

In this study, the Views on Science-Technology-Society (VOSTS) questionnaire, developed by Aikenhead et al. (1989) and adapted into Turkish by Mıhladız (2010), was used.

The VOSTS includes 21 multiple-choice items arranged in eight categories. These categories are Science and Technology, Influence of Society on Science/Technology, Influence of Science/Technology on Society, Influence of School Science on Society, Characteristics of Scientists, Social Construction of Scientific Knowledge, Social Construction of Technology, Nature of Scientific Knowledge (Aikenhead & Ryan, 1992, p.481). The responses of each participant were analyzed using a 3-category coding scheme: realistic, plausible, or naïve (Mıhladız, 2010).

2.3.3. Think-aloud protocol

In order to answer the second research question, the think-aloud protocol was used. The think-aloud strategy is based on asking students to say what they are thinking about something at the moment out loud. 5 pre-service science teachers from the experimental group and 5 pre-service science teachers from the control group were selected according to maximum variation sampling principles for the think-aloud protocol in order to examine their self-regulation behavior in detail.

2.4. Hypermedia learning environment

During the interventions, both of the groups used the hypermedia learning environment (HLE) (www.bilimindogasi.net), which was created by a researchers on a computer to learn about the nature of science (NOS). This HLE contained articles, animations, and videos that were all related to the NOS and comprised about 85 sections and 100 hyperlinks. Participants were limited to the use of only this HLE (www.bilimindogasi.net) while learning and they were asked to use all of the aspects of

the HLE, such as the hyperlinks and search functions, and were allowed to freely navigate it.

2.5. Scaffolding prompts questions for self-regulation

Before the study, a guiding sheet called 'scaffolding prompt questions' was created for the experimental group to encourage them to use their self-regulation behaviors while learning within hypermedia. The 1-page guide sheet was designed according to the Pintrich phases and areas of self-regulation. The general framework of the scaffolding prompt questions included self-regulation variables, as follows:

- Planning learning goals
- Prior knowledge activation
- Planning time
- Using different strategies to learn
- Checking remaining time
- Self-monitoring

2.5.1. Scaffolding Prompt Questions Used in the Study

(1) I should learn the given learning goals at the end of the course

(2) What do I know about that topic?

(3) I should perform timeline/academic time planning

(4) I should implement different strategies to learn them

(5) I should check the remaining time/check timeline

(6) Did I learn each learning goal?

2.6. Procedure

Table 1. Procedure and data collection process in the study

WEEKS	GROUP 1	GROUP 2
(1)	Hypermedia training (PPT presentation)	Hypermedia training (PPT presentation) Self-regulation training
(2)	MSLQ/pretest VOSTS/pretest	MSLQ/pretest VOSTS/pretest
(3)	Directives for the learning task that include the learning goal Learning task in the hypermedia (www.bilimindogasi.net)/100 min. Think aloud (5 students)	Directives for the learning task that include the learning goal Learning task in the hypermedia (www.bilimindogasi.net)/100 min. + scaffolding prompt questions sheet Think aloud (5 students)
(5)	MSLQ/posttest	MSLQ/posttest
(6)	VOSTS/posttest	VOSTS/posttest

The study was conducted in a computer laboratory. In the first week of the study, both of the groups were trained to use the hypermedia environment and only the experimental group (Group 2) was given self-regulation instructions regarding how to regulate their learning using the HLE. During the self-regulation instruction, a researcher explained each of the self-regulation variables presented on the guide sheet (scaffolding prompt questions) and gave examples about the questions on guiding sheet In the second week, the MSLQ was used as a pretest to measure the self-regulation behaviors of the learners at the beginning of the study and also, the VOSTS questionnaire was used to reveal their NOS understandings. In the third week, both groups received an overall learning goal and in addition to this, only the experimental group received a guide sheet, which provided the guide (scaffolding) questions related to self-regulation during the hypermedia learning task. The questions on the guide sheet comprised directive questions to help their self-regulation process. Next, all of the learners were given 100 min to use the hypermedia (www.bilimindogasi.net) to learn about the NOS. Each participant was assigned to a computer, which they used individually while learning from the hypermedia. While learning from the hypermedia, the learners were allowed to take notes. However, during the posttest, they were not allowed to use these notes. Moreover, during the instructional interventions of the study, the think aloud protocol was conducted with 10 pre-service science teachers, who were selected according to maximum variation sampling principles from both groups, in order to examine their self-regulation behavior in detail. Finally, the MSLQ and VOSTS were given to both groups as a posttest after using the hypermedia environment.

2.7. Data Analysis

2.7.1. Motivated strategies for learning questionnaire

The MSLQ data were analyzed using IBM SPSS Statistics for Windows 17.0 (IBM Corp., Armonk, NY, USA). During the data analysis, the independent samples t-test was used.

2.7.2. Views on science-technology-society instrument

In the analysis of the VOSTS instrument, the responses of each participant were analyzed using a 3-category coding scheme: realistic, plausible, or naïve (Mıhladız, 2010). The answers to each option by the pre-service teachers were evaluated by calculating the percentage and frequency. Realistic view indicated an appropriate and contemporary NOS view, Plausible view indicated an unrealistic but logical NOS view, Naïve view indicated a non-realistic or non-acceptable NOS view (Mıhladız, 2010).

2.7.3. Think aloud

In the first phase of the verbal data obtained from the think aloud protocol, researchers transcribed the audiotapes of each participant. Next, the think aloud data were coded for various self-regulating behaviors. The coding scheme was developed by researchers and it was based on several models of self-regulation (Pintrich, 2000; Winne & Perry, 2000; Zimmerman, 2000, 2001; Azevedo et al. 2004).

The think aloud data were coded by a pair of independent raters. Inter-rater reliability, which is the degree of agreement among the raters, was determined as 90%.

In general the coding scheme included these variables:

1. Planning
   - Goal setting
   - Activation of working memory
   - Activation of prior knowledge
2. Self-monitoring
   - Judgment of learning
   - Self-questioning
   - Identifying the adequacy of information
   - Remember learning goals
   - Content evaluation
   - Monitoring time
   - Feeling of knowing

3. Strategy Use
- Re-reading
- Draw
- Summarization
- Using different information sources
- Offering workaround
- Knowledge elaboration
- Free search
- Goal-directed search
- Memorize
- Take notes
- Read notes

4. Motivation
- Interest
- Task difficulty

3. Results

In this section, results were presented in line with research questions as follows:

- Research Question 1: Do the scaffolding prompt questions have an impact on the self-regulation behaviors of pre-service science teachers?

Table 2. Independent samples T-Test scores of the pretest MSLQ

	Factors	Group	N	X	S	t	sd	p
Motivation	Control belief	Group 2	33	20.48	2.71	-.836	62	.407
		Group 1	31	21.03	2.50			
	Intrinsic goal orientation	Group 2	33	21.21	3.66	.175	62	.861
		Group 1	31	21.06	3.01			
	Extrinsic goal orientation	Group 2	33	19.45	4.88	1.237	62	.221
		Group 1	31	17.93	4.93			
	Self-efficacy	Group 2	33	44.09	5.51	.984	62	.329
		Group 1	31	42.45	7.69			
	Task value	Group 2	33	32.78	3.89	.712	62	.479
		Group 1	31	32.06	4.23			
	Test anxiety	Group 2	33	15.93	4.95	-1.141	62	.258
		Group 1	31	17.45	5.64			
Learning Strategies	Performance management	Group 2	33	16.39	3.39	.443	62	.659
		Group 1	31	15.96	4.26			
	Peer learning	Group 2	33	13.33	3.68	-.387	62	.700
		Group 1	31	13.64	2.64			
	Rehearsal	Group 2	33	20.63	4.07	1.067	62	.290
		Group 1	31	19.67	2.99			
	Metacognitive	Group 2	33	59.90	8.62	.020	62	.984
		Group 1	31	59.87	6.00			
	Elaboration	Group 2	33	31.84	5.82	-.569	62	.571
		Group 1	31	32.54	3.72			
	Organization	Group 2	33	22.33	3.75	1.201	62	.234
		Group 1	31	21.32	2.89			
	Time and study environment	Group 2	33	37.15	4.53	.470	62	.640
		Group 1	31	36.61	4.63			
	Critical Thinking	Group 2	33	26.12	3.99	1.196	62	.236
		Group 1	31	25.00	3.46			
	Help Seeking	Group 2	33	19.21	3.36	-.149	62	.882
		Group 1	31	19.35	4.26			

The MSLQ was applied to both groups before the interventions to compare the self-regulation behaviors between the groups. The data showed that no significant difference was found between the 2 groups with regards to control beliefs ($t = –0.836$, $P = 0.407 > 0.05$), intrinsic goal orientation ($t = 0.175$, $P = 0.861 > 0.05$), extrinsic goal orientation ($t = 0.1.237$, $P = 0.221 > 0.05$), self-efficacy ($t = 0.984$, $P = 0.329 > 0.05$), task value ($t = 0.712$, $P = 0.479 > 0.05$), test anxiety ($t = –1.141$, $P = 0.258 > 0.05$), performance management ($t = 0.443$, $P = 0.659 > 0.05$), peer learning ($t = –0. 387$, $P = 0.700 > 0.05$), rehearsal ($t = 1.067$, $P = 0.290 > 0.05$), metacognitive ($t = 0.020$ $P = 0.984 > 0.05$), elaboration ($t = –$

0.569, P = 0.571 > 0.05), organization (t = 1.201 P = 0.234 > 0.05), time and study environment (t = 0.470, P = 0.640 > 0.05), critical thinking (t = 1.196, P = 0.236 > 0.05), or help seeking (t = –0.149, P = 0.882 > 0.05). These findings for the MSLQ sub-dimensions meant that the participants in both groups were at a similar level with regards to self-regulation behaviors before the instructional interventions.

Table 3. Independent samples T-Test scores of the posttest MSLQ

Factors		Group	N	X	S	t	sd	p
Motivation	Control belief	Group 2	33	21.90	2.97	7.424	62	0.000
		Group 1	31	17.03	2.19			
	Intrinsic goal orientation	Group 2	33	22.33	3.06	5.494	62	0.000
		Group 1	31	18.16	3.00			
	Extrinsic goal orientation	Group 2	33	20.09	4.27	2.118	62	0.038
		Group 1	31	17.45	5.63			
	Self-efficacy	Group 2	33	46.06	6.28	5.123	62	0.000
		Group 1	31	38.00	6.29			
	Task value	Group 2	33	34.27	4.07	1.407	62	0.164
		Group 1	31	32.83	4.06			
	Test anxiety	Group 2	33	18.21	6.09	3.148	62	0.003
		Group 1	31	13.90	4.72			
Learning Strategies	Performance management	Group 2	33	17.51	4.25	1.847	62	0.070
		Group 1	31	15.54	4.25			
	Peer learning	Group 2	33	13.84	3.62	5.892	62	0.000
		Group 1	31	9.45	2.09			
	Rehearsal	Group 2	33	21.57	3.76	1.966	62	0.054
		Group 1	31	19.61	4.21			
	Metacognitive	Group 2	33	63.18	6.28	1.872	62	0.066
		Group 1	31	60.22	6.34			
	Elaboration	Group 2	33	34.24	4.63	7.083	62	0.000
		Group 1	31	27.12	3.22			
	Organization	Group 2	33	23.24	2.89	6.291	62	0.000
		Group 1	31	18.64	2.95			
	Time and study environment	Group 2	33	38.75	5.50	.223	62	0.825
		Group 1	31	38.48	4.19			
	Critical thinking	Group 2	33	27.12	4.23	1.685	62	0.097
		Group 1	31	25.41	3.81			
	Help seeking	Group 2	33	20.63	2.93	6.057	62	0.000
		Group 1	31	15.83	3.39			

The findings for the MSLQ posttest showed that there was a significant difference between the MSLQ sub-dimensions of the 2 groups with regards to control beliefs (t =

0.7.424, P = 0.038 < 0.05), intrinsic goal orientation (t = 0.5.494, P = 0.000 < 0.05), extrinsic goal orientation (t = 2.118 P = 0.000 < 0.05), self-efficacy (t = 5.123, P = 0.000 < 0.05), test anxiety (t = 3.148, P = 0.003 < 0.05), performance management (t = 1.847, P = 0.070 < 0.05), peer learning (t = 5.892, P = 0.000 < 0.05), rehearsal (t = 1.966, P = 0.054 < 0.05), metacognitive (t = 1.872, P = 0.066 < 0.05), elaboration (t = 7.083, P = 0.000 < 0.05), organization (t = 6.291, P = 0.000 < 0.05), critical thinking (t = 1.685, P = 0.097 < 0.05), and help seeking (t = 6.057, P = 0.000 < 0.05). However, a significant difference on behalf of the experimental group (Group 2) was found in the MSLQ posttest (P < 0.05).

- Research Question 2: What types of self-regulation behaviors do participants exhibit when learning about NOS within hypermedia?

Table 4. Frequency and percentage distribution of self-regulation behaviors of pre-service teachers in group 1 and group 2

Self-regulation Behaviors	Group 2 (n = 5)		Group 1 (n = 5)	
	f	%	f	%
Planning				
Goal setting	6	85.7	1	14.3
Activation of working memory	31	81.6	7	18.4
Prior knowledge activation	49	49.5	50	50.5
Monitoring				
Judgment of learning (positive)	43	78.2	12	21.8
Judgment of learning (negative)	13	65	7	35
Awareness of knowing (positive)	17	30.4	39	69.6
Awareness of knowing (negative)	4	57.1	3	42.9
Self-questioning	2	40	3	60
Evaluation of content (positive)	9	75	3	25
Evaluation of content (negative)	3	42.9	4	57.1
Content adequacy expectation (positive)	12	75	4	25
Content adequacy expectation (negative)	7	87.5	1	12.5
Monitoring process towards goals	13	76.5	4	23.5
Monitoring the strategies used	8	88.9	1	11.1
Checking time	21	72.4	8	27.6
Using strategy				
Control video	1	14.3	6	85.7
Coordinating information sources	4	100	0	0
Choosing a new information source	124	46.1	145	53.9
Drawing	4	80	1	20
Making inferences	112	53.8	96	46.2
Memorizing	2	40	3	60
Repeat	88	84	17	16
Reviewing notes	48	87.3	7	12.7
Taking notes	219	72	85	28
Goal directed search	65	86.7	10	13.3
Non-goal-directed search	5	4	122	96
Motivation				
Interest (positive)	12	22.2	42	77.8
Interest (negative)	5	41.7	7	58.3

The think aloud protocol data showed that the participants in Group 2, who were given the scaffolding prompt questions, exhibited these self-regulation behaviors more than

those in Group 1: goal setting, activation of working memory, judgment of learning, evaluation of content, content adequacy expectation, monitoring process toward goals, monitoring strategies used, checking time, repeating, reviewing notes, taking notes, and goal-directed search.

- Research Question 3: How does self-regulation affect the NOS understanding of the pre-service science teachers when using the hypermedia?

Table 5. Categorized distribution of the responses of the pre-service teachers to the pretest VOSTS items

NOS Aspects	Group 2			Group 1		
	Naïve %	Plausible %	Realistic %	Naïve %	Plausible %	Realistic %
Defining science	3	27.3	69.7	6.5	16.1	77.4
Influence of society on science	6.1	36.4	54.5	0	58.1	41.9
Influence of society on scientists	12.1	21.2	66.7	6.5	19.4	74.2
Influence of science on society	12.1	84.8	3	16.1	80.6	3.2
Characteristics of scientists	39.4	6.1	54.5	38.7	0	61.3
Characteristics of scientists	36.4	15.2	48.5	29	19.4	51.6
Social structure of scientific knowledge	36.4	6.1	57.6	51.6	3.2	45.2
Nature of observations	51.5	0	48.5	38.7	0	61.3
Nature of scientific models	57.6	6.1	36.4	67.7	6.5	25.8
Nature of classification schemes	21.2	0	78.8	41.9	0	58.1
Tentativeness of scientific knowledge	3	0	97	3.2	0	96.8
Hypotheses, theories and laws	81.8	0	18.2	90.9	0	9.7
Hypotheses, theories and laws	48.5	15.2	36.4	41.9	32.3	25.8
Hypotheses, theories and laws	84.8	0	15.2	80.6	0	19.4
Scientific approach to investigations	54.5	36.4	9.1	25.8	61.3	12.9
Scientific approach to investigations	12.1	0	87.9	9.7	0	90.3
Precision and uncertainty in scientific knowledge	9.1	12.1	78.8	9.7	12.9	77.4
Epistemological status of laws	60.6	12.1	27.3	58.1	22.6	19.4
Epistemological status of hypotheses	66.7	24.2	9.1	61.3	19.4	19.4
Epistemological status of theories	69.7	0	30.3	58.1	3.2	38.7
Coherence of concepts across disciplines	39.4	39.4	21.2	29	48.4	22.6

As seen in Table 5, before the interventions, the pre-service teachers in both groups had naïve and plausible views on the NOS aspects. This finding indicated that pre-service teachers did not have completely realistic views on the NOS, and even naïve views on some issues were more common. Therefore, it can be assumed that the pre-profiles of the pre-service teachers in both groups about the NOS were similar.

Table 6. Categorized distribution of the responses of the pre-service teachers to the posttest VOSTS items

NOS aspects	Group 2			Group 1		
	Naïve %	Plausible %	Realistic %	Naïve %	Plausible %	Realistic %
Defining science	0	9.1	90.9	0	16.1	83.9
Influence of society on science	0	36.4	63.6	0	32.3	67.7
Influence of society on scientists	0	18.2	81.8	6.5	32.3	61.3
Influence of science on society	15.2	60.6	24.2	12.9	87.1	0
Characteristics of scientists	9.1	18.2	72.7	12.9	22.6	64.5
Characteristics of scientists	36.4	18.2	45.5	32.3	6.5	61.3
Social structure of scientific knowledge	9.1	9.1	81.8	12.9	22.6	61.3
Nature of observations	24.2	0	75.8	38.7	3.2	58.1
Nature of scientific models	51.5	15.2	33.3	51.6	22.6	25.8
Nature of classification schemes	9.1	0	90.9	19.4	0	80.6
Tentativeness of scientific knowledge	0	0	100	0	3.2	96.8
Hypotheses, theories and laws	18.2	6.1	75.8	35.5	9.7	54.8
Hypotheses, theories and laws	21.2	36.4	42.4	12.9	25.8	61.3
Hypotheses, theories and laws	81.8	0	18.2	61.3	6.5	32.3
Scientific approach to investigations	15.2	30.3	54.5	12.9	41.9	45.2
Scientific approach to investigations	0	3	97	3.2	3.2	93.5
Precision and uncertainty in scientific knowledge	0	27.3	72.7	9.7	9.7	80.6
Epistemological status of laws	30.3	18.2	51.5	54.8	12.9	32.3
Epistemological status of hypotheses	42.4	18.2	39.4	45.2	29	25.8
Epistemological status of theories	33.3	3	63.6	38.7	6.5	48.4
Coherence of concepts across disciplines	24.2	45.5	30.3	35.5	48.4	16.1

As seen Table 6, after the interventions, conceptual changes occurred in the NOS views in both groups, shifting toward informed views. However, the findings revealed that the pre-service science teachers in Group 2 had a more developed understanding of the NOS than those in Group 1.

4. Discussion and Conclusion

This study explored the impact of the scaffolding prompt questions on the self-regulated learning of pre-service science teachers about the NOS in a hypermedia learning environment.

For the first research question, the findings showed that the scaffolding prompt questions enhance the self-regulation behaviors of the learners. The analysis of the MSLQ indicated that the self-regulation behaviors in both groups were similar before the interventions. On the other hand, a statistically significant difference was found in the posttest scores between these 2 groups after the interventions. Based on this finding, it was concluded that giving self-regulation training before interventions and providing scaffolding prompt questions while learning in a hypermedia environment had a positive effect on the development of self-regulation behaviors in the experimental group.

For the second research question, 5 pre-service teachers from Group 2 and 5 from Group 1 were selected to examine their self-regulation behaviors in-depth. The thinking aloud protocol was applied to these participants and the analysis revealed a significant difference in the usage frequency of the self-regulation behaviors of the learners while learning in the hypermedia environment. The results showed that Group 2 performed better in the 'goal setting and planning and activation of working memory' in the planning stage of the self-regulation than Group 1. These results were consistent with the results of the research conducted by Moss (2007), Azevedo and Cromley (2004), and Turan (2009). Chamot et al. (1999) stated that planning was the first and most crucial stage of self-regulated learning, and students used metacognitive skills in this stage. Moss (2007) also emphasized the importance of using metacognitive skills in learning complex topics in hypermedia. Cheng (2011) concluded that the 'goal setting' self-regulation behavior played a crucial role in the learning performance of students. Moreover, Chamot et al. (1999) indicated that it was insufficient to only perform goal setting and planning at the beginning of learning, it was necessary to remember them repeatedly during the learning process. Thus, they emphasized the importance of 'activation of working memory' and stated the relationship between this behavior and planning. In the planning stage of the study, it was determined that the experimental and control groups showed similar behaviors with regards to 'activating prior knowledge'.

Self-monitoring and strategy use were two2 of the most important stages of self-regulation (Winne & Hadwin, 1998; Winne, 2001). In the self-monitoring phase of self-regulation, Group 2 used more self-regulation behaviors in 'judgment of learning,

evaluation of content, content adequacy expectation, monitoring process towards goals, monitoring the strategies used, and checking time' compared to Group 1. Azevedo and Cromley (2004) emphasized the importance of metacognitive monitoring of the cognitive system in learning. In addition, similar to this study, they also found that students who were given self-regulation training used the 'judgment of learning and monitoring the process towards goals' self-regulation behaviors more than students who were not given self-regulation training. Mih and Mih (2010) emphasized that 'organizing time' was important for effective learning in self-regulation.

It was found that in the strategy use phase of the self-regulation that Group 2 used self-regulation behaviors of 'repeating, reviewing notes, taking notes, and goal-directed search' more than Group 1. It was determined that Group 1 searched in the hypermedia without goal direction. Dodge (2002) asserted that when students used the internet without any aim, the effectiveness of the education was debatable.

For the third research question, it was concluded that the pre-service teachers in both groups had naïve views on most of the aspects of the NOS before the interventions. Abd-El-Khalick and BouJaoude (1997), Yakmacı (1998), Abd-El-Khalick and Akerson (2004), Aslan (2009), Mıhladız (2010) and Arık (2010) also found similar results in their studies. This result may have been due to the insufficient importance given to teaching the NOS at an early age in Turkey and the fact that the teaching of the NOS has only gained importance in recent years.

After the interventions, it was observed that Group 2 shifted from the traditional view to a contemporary view in many aspects of the NOS according to Group 1. On the other hand, Group 2 had more development in their understandings of the NOS than Group 1. This result revealed that the interventions in Group 2 resulted in significant learning. This can be explained by the training of self-regulation behaviors of pre-service teachers in Group 2 and providing scaffolding prompt questions to encourage them to use self-regulation in the learning process. This result was consistent with the literature on the effect of scaffolding on learning (Lawrie et al., 2016; Zheng et al., 2019; Mamun et al., 2020). The findings in the current study confirmed that the scaffolding prompt questions were effective in supporting self-regulated learning.

In summary, hypermedia learning environments have become an increasingly popular educational tool. For this reason, it is vital to conduct studies that guide and inform educators about how to most effectively use these learning environments. With this study, it was aimed to explain the relationship between hypermedia and self-regulation. Based on the results, is suggested that the scaffolding prompt questions sheet used in this study can be placed on the hypermedia screen in future studies. Thus, it can encourage the learner to use more self-regulation behaviors by continually being in front of each page throughout their navigation in the hypermedia. Moreover, the time given to the student to learn can be shown in the upper right or left corner of the hypermedia

screen, and the countdown can start as soon as the student begins the learning process. Thus, the student can better utilize and continuously observe the remaining time on the screen for his/her learning.

This study aimed to detect the self-regulation behaviors of the teachers used in the learning process through the think aloud protocol. This was based solely on the verbal declarations of the participants. However, using the eye-tracking system on the computer and the think aloud protocol, it was possible to determine where the students were looking on the web page and how long they looked at the points that they focused on while learning. In the literature, the difference between students who learned using hypermedia and those who failed to learn was explained as an excess of cognitive load occurring during the learning process. Therefore, the relationship between hypermedia, student achievement, and cognitive load can be investigated in future studies.

No specific measurement for motivation was used in this study, which was an essential part of self-regulation. In future studies, the intrinsic and extrinsic motivations of the students can be evaluated, and their relationship with academic success can be investigated. This study focused on the student (learner) in the self-regulation process. The role of the teacher in developing self-regulation behaviors can be investigated in future studies. Moreover, a different and new method can be attempted to improve the self-regulation behaviors of teacher candidates, and its effectiveness can be investigated.

In this study, the thinking aloud protocol was applied to 10 pre-service teachers to determine in detail the self-regulation behaviors used by learners in the learning process. However, since this constituted the qualitative part of this study, no generalization could be made regarding which self-regulation behavior was an essential determinant of academic achievement. In future studies, a general conclusion can be drawn about which self-regulation behaviors play an active role in academic achievement by applying the think aloud protocol to the whole sample group.

In the study, self-regulation training was given for 2 course hours to improve the self-regulation behaviors of the learners. However, in future studies, a more extended time can be reserved for developing the self-regulation behaviors of the individuals, or the learners can be regularly practice can be performed to develop self-regulation behaviors throughout the academic year, because Cho (2004) emphasized that self-regulation behaviors can be better improved when long-term and regular applications are made.

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