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Web-Based Metacognitive Scaffolding for Internet Search

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Abstract

This study investigates the effects of web-based scaffolding in comparison with teacher scaffolding (TS) and no scaffolding (NS) on students' metacognitive skill development in web-search process. The study utilized a static-group pretest–posttest quasi-experimental design. The first experimental group received web-based Internet search scaffolding (WISS) tool treatment; the second experimental group received TS; and the control group had NS. Receiving WISS during an Internet search had a significant effect on the improvement of metacognitive skills when compared with NS; however, it was not significant when compared with TS. While WISS group's scores in all subscales improved significantly compared with those of NS, TS's strategy generation scores were significantly higher than those of NS group. Moreover, WISS group's *control of attention* scores were significantly higher than those of TS group.

Keywords

Internet search, web-based metacognitive scaffolding, metacognitive skills

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Introduction

The prevalence of Internet-related technologies has brought new challenges for either formal or informal learning settings, and users face dealing with bulk of content on the Web. They are expected to find and evaluate relevant information in addition to integrating the pieces meaningfully to fulfill the searching goals. In line with this expectation, constructivist views of learning assert that the Internet provides students with great sources of information, and it has potential as a supportive learning tool. However, "it is little more than a virtual depository unless that information is transformed into knowledge through meaningful, reflective, active learning activities" (Jonassen, Howland, Moore, & Marra, 2003, p. 49). Therefore, considering the Internet as a massive database or library, self-regulation skills and related constructs such as metacognition become more important than ever before for learners to benefit from the Internet to construct meaning (Howland, Jonassen, & Marra, 2012). In a typical Web-searching scenario, the learner is expected to find, evaluate, and organize the information within the assigned task boundaries. It can be just a look-up search if the main focus is on finding facts. If the task requires critical or creative approach, however, the search process becomes comprehensive (Rieh, Collins-Thompson, Hansen, & Lee, 2016). Although the web-searching interfaces are not sophisticated, tasks including deciding on keywords, examining the search engine results page, eliminating unrelated links, evaluating the reliability or accuracy of information, and choosing what to read demand higher cognitive involvement. In recent years, constructivist paradigm of learning affected formal education settings, thereby related approaches such as problem-based and project-based learning became popular especially in science and technology courses at different levels. Such learning environments require scientific processes in which students are required to perform a good deal of information searching in the Internet (Jonassen et al., 2003 p. 54). Both problem-solving and Web-searching processes are quite similar. They start with understanding the problem or task and continue within an iterative cycle until the solution or the information is found. Because experiments and the interpretation of data and information are the backbones of scientific inquiry, becoming aware of the cognitive processes and managing them during an inquiry are essential parts of constructive educational settings. At that point, developing metacognitive skills of learners in information search process becomes important due to its insightful nature toward cognition. To be able to make sense out of the information search, learners should develop self-regularity skills, and they should be able to plan, use strategies, and evaluate and triangulate resources (Howland et al., 2012). To develop such skills, it is important to provide learners with scaffolding during the search process until they become competent in those skills.

There are many studies concluding the positive effects of metacognitive scaffolding (e.g., Feyzi-Behnagh et al., 2014; Selberg, 1999; Stadtler & Bromme, 2008; Walton & Archer, 2004; Wesiak et al., 2014; Wu & Pedersen, 2011). In a classical study, Azevedo, Winters, and Moos (2004) used a web-based simulation named RiverWeb Water Quality Simulator with eleventh and twelfth-grade high school students in order to find out the effects of self-regulated learning of low achievers and the scaffolding of teachers. The results indicated that low achievers gained little benefit from the web-based simulation. The authors conclude that the necessary self-regulation skills to gain maximum benefit from such a rich environment do not exist in all students. Strategies and monitoring were the most frequently used variables of self-regulation during the treatment, but the quantity and quality of these metacognitive activities were not adequate to gain much from this rich environment. At this point, scaffolding is crucial for successful learning (Graesser, McNamara, & VanLehn, 2005).

Although the definition included the scaffolding by means of a person, electronic elements were also involved in the category as computers and hypermedia became prevalent (Cagiltay, 2006). Hypermedia environments have been used frequently by researchers as both cognitive and metacognitive tools (e.g., Azevedo, 2002; Dillon & Gabbard, 1998; Palaigeorgiou, Despotakis, Demetriadis, & Tsoukalas, 2006; Yildirim, 2005). In their study, White and Frederiksen (2005) used software-based scaffolding rather than the teacher. Inquiry Island is a software designed to scaffold and support fifth graders during inquiries. Students who received the treatment showed significant gain in metacognition in comparison to the other participants who received traditional treatment. Azevedo (2005) states that challenging science topics can be learned with hypermedia if teachers give appropriate scaffolding. Scaffolding is important for deep inquiry and metacognitive strategies (Graesser et al., 2005). Similar to White and Frederiksen's (2005) approach, in a study comparing the effects of computer-based versus teacher-based metacognitive scaffolding, continuous and faded options were distinguished (Wu & Pedersen, 2011). Regarding the improvement in scientific skills, those receiving both continuous computer-based procedural scaffolding and early teacher-based metacognitive scaffolding performed significantly better. On the other hand, none of the groups had significant learning results. In their study, Wolf, Brush, and Saye (2003) investigated the effects of metacognitive scaffolding on metacognitive skill improvement with eighth-grade students. They used Eisenberg and Berkowitz's Information Problem-Solving model as a metacognitive scaffold. The findings showed that control group's work included irrelevant articles. They also used one source of information, while the experimental group preferred to use various resources.

It can be concluded that scaffolding generates positive results on metacognitive skill improvement in most studies. As cited, the number of studies that investigate metacognitive scaffolding for Internet search through a tool is limited, and most of them investigated teacher scaffolding (TS). However, it is difficult for teachers to monitor all students and to provide scaffolding in Internet-searching processes. In addition, TS out of school settings can be challenging. Social networking sites can make metacognitive scaffolding easier in addition to enhancing the learning performance (Jumaat & Tasir, 2015), but it is still effortful. The positive effect of metacognitive scaffolding is clear in the literature, and it goes beyond TS. The ones investigating tool-based metacognitive scaffolding generally has a limited scope of context such as domain of history (Poitras & Lajoie, 2014), physics (Chen, 2014), and computer programming (Mohd Rum & Ismail, 2017). This study aims to approach metacognitive scaffolding in a more general perspective through the utilization of a web-based tool for Internet searching.

Conceptual Foundations

Having its roots from ancient Greek, *metacognition* means beyond cognition. Flavell (1976) defined metacognition as "active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects or data on which they bear, usually in the service of some concrete goal or objective" (p. 232). This is actually not a new phenomenon, probably coined by early philosophers of ancient Greek. Martinez (2006) explains that Socrates had trained his students in order to improve their metacognition, which is known as Socratic dialogue. There are many models of metacognition proposed by different researchers including Kluwe (1982), A. L. Brown (1987), and Nelson and Narens (1990), but Flavell's (1979) model is the earliest one. In his model of cognitive monitoring, Flavell (1979) defined four components including *metacognitive knowledge, metacognitive experience, goals (tasks)*, and *actions (strategies)*. The model assumed that interactions among these components result in monitoring process. Unlike other models, a recent model, proposed by Tobias and Everson (2002), considered a hierarchical relationship among components, which are planning, strategies, evaluating, monitoring, and control. They state that the knowledge monitoring enables other components to be activated. In Bloom's original taxonomy, similar components exist within a hierarchical structure. Bloom is closely associated with the concept of metacognition (Martinez, 2006) in a way to improve higher order thinking skills. In Bloom's revised taxonomy, the combination of creation and metacognition is the ultimate goal in cognitive domain (Anderson & Krathwohl, 2001). Moreover, it does not start with knowing anymore, owing to countless number of resources including the Internet, the first cognitive stage has turned into remembering. This can refer to remembering how to search, what keywords to use, where to search, and so on, and therefore, these questions are already familiar with the metacognition phenomenon.

Both models of metacognition and taxonomies of learning in cognitive domain have similar focus on finding, eliminating, using, evaluating, and even creating information, which can be labeled as metacognitive skills. Lazonder and Rouet (2007) define the term as "the ability to plan, monitor, and evaluate one's own actions" (p. 7) and these skills can be converted into the following in the Internet environment: planning a search, monitoring the progress, and evaluating the search outcomes. These skills are similar to Quintana, Zhang, and Krajcik's (2005) categorization of metacognitive challenges faced during a web inquiry, which are categorized into three parts: The metacognitive challenges in the framework are categorized into three parts: (a) task understanding and planning, (b) monitoring, and (c) regulation reflection. The first category consists of knowledge of cognitive nature, demands, strategies related to tasks, and a series of actions. The second category includes the identification of the current task, evaluation of the progress, prediction of outcomes, decisions for distribution of resources, and speed and intensity of steps. The last category includes a deliberate thinking process on the whole cognition.

Metacognitive skills are different from metacognitive knowledge, which can be defined as the knowledge about own and other's cognitive processes. The former emphasizes on self-regulatory activities throughout the problem-solving process (Veenman, Prins, & Elshout, 2002), whereas the latter is contingent upon the interaction between characteristics of person and task and available strategies (Flavell, 1979). While metacognitive skills require procedural knowledge, the other deals with declarative knowledge (Veenman & Spaans, 2005). In short, considering different metacognition models, metacognitive knowledge can be associated with the knowledge of cognition, and metacognitive skills are related to the regulation of cognition. Metacognitive knowledge increases and develops after the ages of 4 to 6 years, and when children come to the age of 11 to 12 years, metacognitive skills starts to be improved and there is enough evidence in the literature about the successful trainings of metacognitive skills (Veenman & Spaans, 2005). Individual's metacognitive skills have influences either on learning process or achievement (Sánchez-Alonso & Vovides, 2007) and they can be improved with the help of practice (Flavell, 1979).

In the literature, there are some practical and theoretical approaches to improve metacognitive skills. For example, modeling during problem-solving process is one of these approaches (Garii, 2002; Martinez, 2006; Mathan & Koedinger, 2005). Computers are especially effective in modeling the metacognitive strategies (Lin, Schwartz, & Hatano, 2005). In modeling, the selection of problem-solving tasks is critical because they should be rich in metacognitive skills as well as content (G. Brown, 1984). In this way, engaging in the tasks can contribute to the development of metacognitive skills. G. Brown (1984) focuses on the importance of metacognitive skills for the improvement of children's cognitions; therefore, metacognition can lead success at certain points where formal disciplines fail. It is known that metacognitive skills are improved by practice, and thus may need to be shaped by external scaffolding when children reached appropriate developmental level.

Scaffolding can be defined as the support provided for learning to occur and for enabling learners to become independent or self-regulated learners (Woolfolk, 2007). Scaffolding as a concept is closely related with the *zone of proximal development* concept of Vygotsky. It simply explains that an individual has certain abilities, which are obvious and certain potential for further ones but incapable of doing by oneself. The limits of the existing abilities can be enlarged with the help of certain help of more experienced agents like a peer, an adult, or even a virtual learning agent. In this way, learners can move from one zone to the next. Throughout the development, scaffolding is at the core of the whole progress. Wood, Bruner, and Ross (1976) made an explicit definition of scaffolding as follows: "adult controlling those elements of the task that are initially beyond the learner's capacity" (p. 90). Hannafin, Land, and Oliver (1999) divided scaffolding into four: *conceptual, procedural, strategic,* and *metacognitive scaffolding*. Metacognitive scaffolding can be defined as the interventions to foster students' use of strategies and help them to improve and become self-regulated ultimately. The aim of this type of scaffolding is to show the student the ways to monitor their own cognition and learning process, to control the process, and to evaluate and reflect on the process. It can be either domain specific or general. Like other scaffolds, metacognitive scaffolds have been studied for more than two decades. Since the introduction of the term, its use has spread across different areas.

This Study

In the literature, there is a tendency toward the high benefits of metacognitive scaffolding, but the studies including software-based or web-based metacognitive scaffolding are limited in quantity. A group of studies compares conditions without inclusion of teachers (e.g., Delen, Liew, & Willson, 2014; Kim & Pedersen, 2011), whereas a group of researchers includes both teacher-based and technology-based conditions (e.g., Raes, Schellens, DeWever, & Vanderhoven, 2012). Although the designs of the studies are different, there are certain common tendencies with regard to results. They report that metacognitive scaffolding has the potential to facilitate learning. Moreover, regardless of the provider, prompts are highly efficient scaffolds (Devolder, van Braak, & Tondeur, 2012). On the other hand, within limited amount of studies comparing TS with web-based scaffolding, the results show varying benefits. For example, in Raes et al.'s (2012) study, teacher-based scaffolding is found beneficial in terms of knowledge acquisition but appeal more to girls and low achievers. Yet, the same study reports the benefits of web-based scaffolding on metacognitive awareness. It is obvious that dynamic scaffolds provided by teachers (or any similar agent) can appeal learners more (Kim & Hannafin, 2010), but what happens when the same metacognitive scaffolds are provided by two different agents, that is, teachers versus web-based tool is a question that remains to be answered. In this study, the main aim is to understand the effects of web-based metacognitive scaffolding in comparison with TS and no scaffolding (NS) on students' overall metacognitive skill development. As each metacognitive skill has its own characteristic, we also aim to explore if the effects are valid for subdimensions such as monitoring. Hence, the following research questions guided this study:

> Does receiving WISS significantly affect the improvement of metacognitive skills in comparison to TS and NS conditions when initial metacognitive skills are controlled?
>
> Does receiving WISS significantly affect the improvement of sub-metacognitive skills including reflection-regulation, monitoring, planning, control of attention, and strategy generation in comparison to TS and NS conditions?

Method

This study utilizes a static-group pretest–posttest quasi-experimental design. There are two experimental groups and one control group. The intact groups, that is, three classes in a public school, were assigned randomly to one of the groups. The first experimental group received web-based Internet search scaffolding (WISS), the second experimental group received TS, and the control group had NS. Table 1 demonstrated the design of the study. Metacognition Inventory for Internet Search (MIIS) was used to measure students' metacognitive skills for Internet search before the study and at the end of the study.

Subjects

A convenient public elementary school, which was located in the urban area and had one computer laboratory with 30 computers, was selected for the study. There were 3 seventh-grade classes in the school. The subjects could not be assigned randomly to one of the groups because of the school regulations and inflexible schedules. Instead, intact groups were assigned randomly to the treatments as WISS, TS, and NS groups. There were 76 subjects in total. TS group included 25 students and WISS group and the control group had 26 students each. However, at the end of the study, there were 23 valid data for TS group, 25 for WISS group, and 24 for NS group. As a result, 72 (43 females and 29 males) students participated in the study. The subjects took Information Technology and Software course during their previous semesters, and they were experienced in using the Internet for information search purposes. In addition, because of

Table 1. Static-Group Pretest–Posttest Design of the Study.

Group	Pretest	Tasks and treatments	Posttest
Web-based internet search scaffolding	MIIS	(1) 15-minute training for the software. (2) 5 search tasks (40 minutes for each) during 5 weeks. (a) Search the Internet to find out information according to given topics from science and technology curriculum with the help of *software*. (b) Logs (users' answers, keywords, time and number of web-site visits, number of trials, rank of visited sites, previous knowledge of users, and aim of their search) were recorded.	MIIS
Teacher scaffolding	MIIS	(1) Five search tasks (40 minutes for each) during 5 weeks. (a) Search the Internet to find out the information according to given topics from science and technology curriculum with the scaffold of *teacher.* (b) Screen shots were recorded with the help of Snagit software.	MIIS
No scaffolding	MIIS	(1) Five search tasks (40 minutes for each) during 5 weeks. (a) Search the Internet to find out the information according to given topics from science and technology curriculum *without any help*. (b) Screen shots were recorded with the help of Snagit software.	MIIS

Note. MISS = metacognition inventory for Internet search.

the requirements of the elementary school curriculum, almost all students of any grades frequently experience assignments that require Internet search. Depending on the subject area, students conduct web searches at least once a week. The same science and technology teacher and the same information technology and software teacher had taught the related courses to all three classes. In addition, subjects have been exposed to the same science and technology curriculum and the same information technology and software curriculum.

Procedures and Search Tasks

Procedures. The treatments took place during regular class hours, 40 minutes per week, and lasted for 5 weeks. Before the study, students were given MIIS, and those who are in WISS group received a 15-minute training about how to use WISS tool. Each week, the science and technology teacher taught the content from the current unit of science and technology curriculum first, and then a search task about the covered content was given to the subjects in all groups. They performed five search tasks that were different for each week. Each search task included one fact-finding and one interpretation question. For the science and technology teacher, all contents and their orders were the same for all groups.

WISS group: The first experimental group (WISS) searched the assigned topics on the Web with the help of WISS software providing scaffolding of metacognitive processes through question–answer method. Students' search logs were recorded by the tool. This specific web-based metacognitive scaffolding application, WISS (Sendurur & Yildirim, 2015) was developed according to the online inquiry principles stated by Quintana et al. (2005). The tool served the needs of scaffolding as well as the support for metacognitive skill improvement throughout the Internet search. The tool aimed to help searchers without any assistance of the teacher and had four components with the following strategies.

- *Asking question*: Provide driving questions, help to integrate results of multiple searches in one space.
- *Searching*: Encourage users to find rich resources, make search steps visible, help users to decide on keywords before searching, and show the search history.
- *Evaluating and reading*: Provide a prompted notepad, show users their goals, and provide users with a list of evaluation criteria.
- *Synthesizing*: Encourage users to compare and contrast information across different resources, describe the criteria they should use, and prompt users to reflect on different aspects of information.

In a typical search task, users are expected to start the search by entering the keywords, aim, and the previous knowledge. Then, the generated results are examined to choose what to visit next. If the user finds a relevant link, she or he visits that website. If there is nothing meaningful on the list, the user can decide either to change the keywords or to revisit the results. Reading module starts when the user clicks on the web site's link. In this module, users can take notes by provided citation button. While leaving the page, users are encouraged to think about their reading performance through answering the presented questions about relevance and security of information. In this module, users also have to decide on what to do next. If they decide to continue the search, they go back to

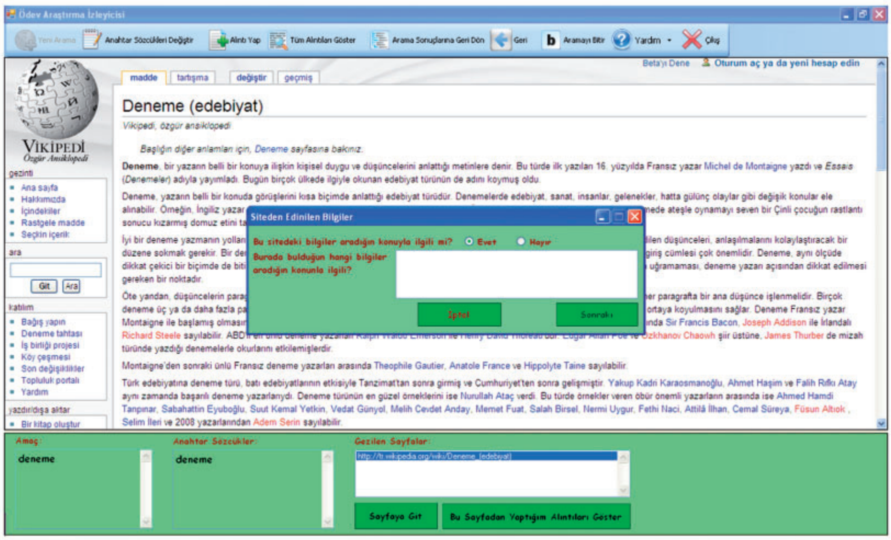

Figure 1. Screenshot of WISST (Sendurur & Yildirim, 2015).

start module with either new or previous keywords. On the other hand, they have option to choose ending the whole search and then enter needed information about their whole search. Exit button is accessible anytime and anywhere in the software. Figure 1 demonstrates the screenshot of the tool's last version.

TS group: The second experimental group (TS) received teacher scaffolding. Before the experiment, the teacher was provided with resources on how to scaffold students during Web search activity. Then, the teacher received a 2-week training and practiced skills such as metacognitive modeling, strategy use, and scaffolding with several students. In TS group, the teacher followed the similar strategies with the WISS, but the scaffolding agent was the teacher. The teacher helped and modeled students to think in a critical way and tried to shape their Internet search process within assigned tasks. The students used Google search engine for their search tasks, and their search sessions were recorded via Snagit software.

NS group: In this group, students did not use WISS. They searched the Internet via Google search engine. Students' search sessions were recorded via Snagit software. Students freely searched the web without any interventions except for the physical existence of the teacher who did not guide students.

Search tasks. The topic of the first week was *global warming*. The search task included two questions:

1. What is global warming?

2. In your opinion, what might be the negative effects of global warming on human life?

The topic of the second week was *tropical fruits*. The search questions were as follows:

1. Find information about a fruit that does not grow in Turkey but somewhere in the world.
2. In your opinion, why doesn't that fruit grow in Turkey?

The topic of the third week was *noise pollution*. The search questions were as follows:

1. What are the reasons of noise pollution?
2. In your opinion, what can be the ways to reduce or eliminate the noise pollution?

The topic of the fourth week was *soil types*. The format of the question was changed because the original one required only collection of information, but due to the purposes of this study, it was turned into a combination of data collection and synthesizing. The search questions were as follows:

1. What are the differences between mold and clayey soil types?
2. In your opinion, which one might be more appropriate for agriculture? Explain your reasoning.

The topic of the fifth week was *respiratory system*. The search questions were as follows:

1. Find information about three respiratory system illnesses.
2. In your opinion, which of these illnesses might be the most dangerous one? Explain your reasoning.

Data Collection Instrument

MIIS (Sendurur & Yildirim, 2008) aims to measure sixth-, seventh-, and eighth-grade students' metacognitive skills experienced during the Internet search. The inventory (Cronbach $\alpha = .83$) consisted of 37 4-point (1 refers to *never*, 2 refers to *sometimes*, 3 refers to *often*, and 4 refers to *always*) Likert-type items. In developing the inventory, three basic procedures were applied. First, an item pool was generated based on Quintana et al.'s (2005) framework specific to the Internet search and metacognitive challenges faced during the search process. After expert reviews and cognitive interviews with two students, 37-item MIIS was developed and pilot exploratory factor analysis was conducted. Second, the final version of the scale was distributed to 273 seventh-grade students, and the existing constructs were extracted through exploratory factors analysis. Third, 321 seventh graders completed the revised version of MIIS, and then the data were used for confirmatory factor analysis. As a follow-up, test–retest reliability was tested with 101 sixth graders. Correlation between the results of first administration of the whole scale and the second administration, after 4 weeks, was found to be significant ($r_{MIIS} = .84$, $p < .01$). Correlation coefficients for factors were also significant. The subscales of the inventory found through the final analysis were named as follows:

- (i) Reflection and regulation (Cronbach $\alpha = .74$): Reflection skill refers to both conscious thoughts about the learning process as a result of monitoring process and decisions to accomplish goals (Mcalpine, Weston, Beauchamp, Wiseman, & Beauchamp, 1999). Regulation skills also refer to allocation of resources, ordering the steps, deciding on the intensity, and speed of the studying (Kluwe, 1982). An example item; "After finishing my Internet search, I think about whether found information is adequate for my homework."
- (ii) Monitoring (Cronbach $\alpha = .76$): Monitoring can be defined as series of information about the individual's own introspections, whereas controlling can be defined as the skill that modifies the object level through certain actions (Nelson & Narens, 1990). In this study, control actions were limited to Internet search environment. For example, online chatting with friends while conducting a web search task might be a sign of lack of attention control. An example item; "While examining a site, I easily distinguish the information that can be used in my homework."
- (iii) Planning (Cronbach $\alpha = .75$): Planning skill is similar to regulation due to the involvement of a series of decisions about resources, strategies, and order of steps (Woolfolk, 2007). An example item, "Before starting the Internet search, I decide on basic key words."
- (iv) Control of attention (Cronbach $\alpha = .70$): Control skills refer to processes providing with behavior change or direction and they are self-regulative in nature (Cary & Reder, 2002). In a web search process, control of attention skill involves the control of any disturbing behavior to move forward. An example item, "During the examination of sites related to my homework, I chat with my friends."
- (v) Strategy generation (Cronbach $\alpha = .68$): Strategy generation skills refer to adjustments made to achieve goals (Flavell, 1979). An example item, "I take some notes about examined Web sites."

Results

The Effects of WISS on Metacognitive Skill Improvement in Comparison to TS and NS

In this section, we explored the following hypotheses:

> H_0: There are no significant mean differences between Web-based Internet Search Scaffolding (WISS), Teacher Scaffolding (TS) and No Scaffolding (NS) groups' post-Metacognition Inventory for Internet Search (MIIS) scores at the end of the experiment when their pre-MIIS scores are controlled.
>
> $H_{a:}$ There are significant mean differences between WISS, TS, and NS groups' post-MIIS scores at the end of the experiment when their pre-MIIS scores are controlled.

Descriptive findings for post-MIIS are presented in Table 2. To find out the significant differences of metacognitive skill improvement among three groups, we planned to use variance analysis. As the students were not randomly assigned, we decided to include their beginning metacognitive skills as a control variable, and thus analysis of covariance (ANCOVA) is an appropriate test for this purpose. All assumptions of ANCOVA were met.

The results of the ANCOVA analysis showed that pre-MIIS scores have significant effects on post-MIIS scores of students, $F(1, 68) = 19.08$, $p < .05$, $r = .22$. Moreover, belonging to one of the experiment groups, $F(2, 68) = 6.03$, $p < .05$, $r = .15$, have also significant effects on post scores with small effect sizes, and thus, we can reject the null hypothesis. Table 3 summarizes the results of ANCOVA.

The comparisons (Bonferroni) revealed that receiving WISS significantly improved metacognitive skills compared with receiving NS, $t(68) = 3.40$, $p < .05$, $r = .15$. The summary of comparisons was summarized in Table 4.

Table 2. Mean, *SD*, Min, and Max Values of Dependent Variables.

	WISS		TS		NS	
	Pre-MIIS	Post-MIIS	Pre-MIIS	Post-MIIS	Pre-MIIS	Post-MIIS
N	25	25	23	23	24	24
Mean	88.8	98.2	86.83	95.13	87.67	90.42
Min	58	73	76	83	62	71
Max	105	113	100	107	107	107
SD	11.24	8.46	6.42	6.88	11.41	9.66

Note. WISS = Web-based Internet search scaffolding; TS = teacher scaffolding; NS = no scaffolding; MISS = metacognition inventory for Internet search.

Table 3. ANCOVA Summary.

	SS	*df*	*MS*	*F*	η^2
Pre-MIIS	1074.30	1	1074.30	19.08*	.22
Group	678.62	2	339.31	6.03*	.15
Error	3829.51	68	56.32		

Note. η^2=effect size; ANCOVA = analysis of covariance; MIIS = metacognition inventory for Internet search.
*$p < .05$.

Table 4. Comparisons among groups: Metacognitive skills.

			95% CI	
Comparisons	Mean difference	Standard error	Lower bound	Upper bound
WISS versus TS	2.25	2.18	−3.09	7.59
WISS versus NS	7.30*	2.15	2.03	12.57
TS versus NS	5.05	2.19	−.33	10.42

Note. WISS = Web-based Internet search scaffolding; TS = teacher scaffolding; NS = no scaffolding.
*$p<.0167$; SS = sum of squares; MS = mean square.

In conclusion, students in WISS group significantly had better metacognitive skill improvement than students in NS group. On the other hand, there was not any significant difference between WISS and TS group.

The Effects of WISS on Specific Metacognitive Skill Improvement in Comparison to TS and NS: Reflection-Regulation, Monitoring, Planning, Control of Attention, and Strategy Generation

In this section, we explored the following hypotheses:

> $H_{0:}$ There are no significant mean differences between WISS, TS, and NS groups' post reflection and regulation, monitoring, planning, control of attention, and strategy generation scores.
>
> $H_{a:}$ There are significant mean differences between WISS, TS, and NS groups' postreflection and regulation, monitoring, planning, control of attention, and strategy generation scores.

ANCOVA results indicated that there are differences on the posttest scores of students attending different groups; therefore, digging into post-MIIS dimensions might be helpful in order to understand which subscores vary across groups. Descriptive findings of five dependent variables (DV; post-MIIS

Table 5. *M* and *SD* Values of Dependent Variables.

			TS		NS	
WISS	*M*	*SD*	*M*	*SD*	*M*	*SD*
Reflection-regulation	3.34	.51	3.23	.49	3.00	.52
Monitoring	3.62	.38	3.51	.36	3.28	.41
Planning	3.60	.40	3.23	.61	3.04	.58
Control of attention	2.97	.49	2.47	.78	2.43	.55
Strategy generation	3.33	.64	3.18	.40	2.79	.49

Note. TS = teacher scaffolding; NS = no scaffolding.

Table 6. Multivariate and Univariate Analysis of Variance *F* ratios for Groups With Three Levels (WISS, TS, and NS) on Students' Submetacognitive Skills.

		ANOVA				
	MANOVA	Reflection-regulation	Monitoring	Planning	Control of attention	Strategy generation
Variable	*F* (10, 132)	*F* (2, 69)	*F* (2, 69)	*F* (2, 69)	*F* (2, 69)	*F* (2, 69)
Groups (IV)	3.20*	3.09	4.90**	6.91**	5.94**	6.74**

Note. ANOVA = analysis of variance; MANOVA = multivariate analysis of variance; IV = independent variable.
*$p < .05$. **$p < .01$.

scores: reflection-regulation, monitoring, planning, control of attention, and strategy generation) and one independent variable with three levels (WISS, TS, and NS) were included in one-way multivariate ANOVA (MANOVA; see Table 5). Before starting the main analysis, certain assumptions were checked. All assumptions were met, but Box's M test, which is very sensitive to sample size, generated a significant value, $F(30, 14945) = 1.74$, $p < .05$. In other words, covariances among DVs are not the same or similar. Instead of Wilk's Lambda, Pillai's trace was preferred to use for further interpretations of MANOVA results because it is robust to such violations.

MANOVA results indicated that attending WISS, TS, or NS groups has multivariate effects on one or more submetacognitive skill improvement, Pillai's $V = .39$, $F(10, 132) = 3.20$, $p < .05$, $r = .20$. We reject the null hypothesis. Investigating the univariate analysis, *monitoring*, *planning*, *control of attention*, and *strategy generation* skills were found significant with small effect sizes, $F_{\text{monitoring}}(2, 69) = 4.90$, $p < .01$, $\eta^2 = .12$; $F_{\text{plan}}(2, 69) = 6.91$, $p < .01$, $\eta^2 = .17$; $F_{\text{control}}(2, 69) = 5.94$, $p < .01$, $\eta^2 = .15$; $F_{\text{strategy}}(2, 69) = 6.74$, $p < .01$, $\eta^2 = .16$. Only *reflection-regulation* skill was insignificant (Table 6).

Table 7. Comparisons among groups: Sub-metacognitive skills.

DV	Comparisons	Mean difference	Standard error	95% CI Lower bound	95% CI Upper bound
Reflection-Regulation	WISS versus TS	.112	.147	−.26	.48
	WISS versus NS	.354	.145	−.01	.72
	TS versus NS	.242	.148	−.13	.61
Monitoring	WISS versus TS	.103	.111	−.18	.38
	WISS versus NS	.337*	.110	.06	.61
	TS versus NS	.234	.112	−.05	.51
Planning	WISS versus TS	.365	.155	−.21	.75
	WISS versus NS	.558*	.153	.176	.94
	TS versus NS	.193	.156	−.20	.58
Control of attention	WISS versus TS	.498*	.177	.06	.94
	WISS versus NS	.543*	.175	.11	.98
	TS versus NS	.045	.179	−.40	.49
Strategy generation	WISS versus TS	.145	.152	−.24	.53
	WISS versus NS	.536*	.151	.16	.91
	TS versus NS	.391*	.154	.01	.78

Note. WISS = Web-based Internet search scaffolding; TS = teacher scaffolding; NS = no scaffolding.
*$p<.0167$.

Post hoc comparisons were investigated for each DV to see which group performed better with regard to four different submetacognitive skills. Scheffe test points that students in WISS condition had significantly higher scores of monitoring, planning, control of attention, and strategy generation than those in NS condition ($p < .05$). Control of attention scores of students in WISS group were also significantly higher than those in TS condition ($p < .05$). Students in TS group performed significantly higher only at strategy generation scores ($p < .05$) than those in NS group. Table 7 summarizes the comparisons.

To sum up, the control of attention skills was improved more with the inclusion of WISS. For the improvement of strategy generation skills, receiving either WISS or TS contributed more than NS. On the other hand, for the improvement of planning and monitoring skills, receiving WISS is better than NS, but the same effect does not exist in comparison to TS. As a final point, reflection and regulation skill improvement was not found affected by any of the three conditions.

Discussion and Conclusion

The effects of scaffolding were explored in many contexts in the literature. This study is an example showing positive effects of metacognitive scaffolding within school settings through utilization of regular search tasks. The results of analysis indicated that receiving web-based metacognitive scaffolds during an Internet search had a significant effect on the improvement of metacognitive skills when compared with NS condition; however, it was not significant when compared with teacher-based metacognitive scaffolding condition. Further analysis revealed a moderate effect of either scaffolding conditions in terms of specific metacognitive skills. While WISS group's scores in *monitoring, planning, control of attention,* and *strategy generation* improved significantly compared with NS group's scores, TS group's *strategy generation* scores were significantly higher than that of NS group. Comparing the WISS and TS groups resulted in significantly higher *control of attention* scores of WISS group. The tool was developed based upon Quintana et al.'s (2005) framework "for supporting metacognitive process of online inquiry through software-based scaffolding" (p. 102) after four iterations with the target students and was finalized through usability testing with the help of eye-tracker (Sendurur & Yildirim, 2015). It can be concluded that the tool has foundations of metacognitive scaffolding principles and the students' needs and preferences. Therefore, the design and development of the tool might have the positive effect on the results.

Considering the results, students in WISS group seemed to benefit the most from metacognitive scaffolding. This finding is parallel to recent studies (Feyzi-Behnagh et al., 2014; Huertas, Lopez, & Sanabria, 2017; Wesiak et al., 2014; Wu & Pedersen, 2011). The only difference between WISS and TS group was the scaffolding medium (computer vs. teacher). Both groups had higher *strategy generation* skills at the end of the study, which can be attributed to the success of metacognitive scaffolding. Modeling students how to apply these strategies and allowing students to practice them are important parts of metacognitive scaffolding. In this way, regardless of the medium, students' strategy generation skills might have developed during the study. WISS group's improvement in *control of attention* was greater than that of TS. This can be the result of deficiencies in TS, that is, the teacher had to deal with 23 students at the same time although their needs for scaffolding varied regarding the time and intensity, thus students might have got distracted while waiting for scaffolding. To sum up, both types of metacognitive scaffolding can help learners develop their strategy generation skills especially while facilitating other skill improvement, except for *reflection-regulation* skill. The medium via which metacognitive scaffolding was provided can be taken into consideration when the control of attention was the skill to be improved. The findings about metacognitive scaffolding are in line with the previous studies (Lazonder & Rouet, 2007; Selberg, 1999; Walton & Archer, 2004; Wesiak et al., 2014). It is important to note that scaffolding is necessary to develop students' metacognitive skills for Internet search. However, a teacher is able to provide metacognitive support for students mostly in school settings in a limited amount of time. Tools like WISS allow students to get metacognitive scaffolding not only in formal school settings but also out of school settings individually. Therefore, it can be stated that WISS is a promising tool to develop students' metacognitive skills for Internet search. In order to provide a smarter and sensitive scaffolding platform that is based on fading, practitioners can benefit the structure and pedagogical background of such tools as WISS.

Metacognitive scaffolding regardless of the scaffolding agent contributed to *strategy generation* skills. As this skill was not developed significantly among nonscaffolded group, it can be inferred that modeling with the help of metacognitive scaffolds has the potential to encourage students to make use of strategies. Such metacognitive skills can be improved with practice (Flavell, 1979; Kelemen, Winningham, & Weaver, 2007). Regular classroom practices as well as outside classroom activities can allow students to practice with real tasks. When compared to the web-based scaffolding, teacher-based scaffolding was found weaker especially in terms of control of attention skills improvement. This is very hard to accomplish for teachers within crowded classrooms. Scaffolding such as modeling might be easier for teachers to apply, but detecting and providing support in time might be harder. This latency can cause some gaps in attention.

This study also confirmed the effective use of metacognitive scaffolding when embedded into computers. In practice, these scaffolds can be embedded into different technologies. As students become familiar with tablet computers, the importance of such scaffolding approaches may become crucial to shape students' interactions with the Internet and guide them to improve their online skills and metacognitive skills. This is necessary because, although students can be considered as digital natives, this might not mean the overall appropriate uses of computers. This might not mean they all have needed skills or make use of skills. That is why these skills including reflection-regulation, monitoring, planning, control of attention, and strategy generation skills should be taken into account by educators who should pay attention to make the skills explicit. Internet search skills should be integrated to the lessons rather than giving as separate instructions. In this way, students can develop their skills while engaging in the real tasks. Web-based metacognitive scaffolds may make a difference if used in a structured way. Self-regulation is a crucial skill especially in e-learning context. The similar adaptive or automated scaffolding platforms may help to diminish the drop-off rates in learning situations occurring at a distance.

This study was conducted in regular school settings and included only one subject area. Different domains can be included in the study to compare the effects of web-based or teacher-based metacognitive scaffolding. The tasks were all under the curriculum of science and technology course. The results might be very different if the tasks are selected from Mathematics or other subjects in the curriculum. Further research is needed in different subject areas. The tasks used in the study were selected with the help of science and technology teacher.

In spite of varying difficulties, they were not given in a purposeful sequence. Future studies can also design the study in accordance with such sequences as simple to complex or vice versa.

A few researchers have studied embedding metacognitive scaffolds into computer environment. This study's results were in favor of web-based metacognitive scaffolding compared to the teacher-based one in Internet search task. For further implications, different types of scaffoldings can be compared with web-based scaffolding that might lead deeper understandings of the impact. As students are being exposed to various types of media, there is a need for adaptation of this tool to different devices. At that point, students' search habits and patterns or even their styles of reading and comprehension may change. These situations need to be explored in Internet search context or any other interaction cases. Metacognitive scaffolding can earn new implications in such mobile interactions.

The study took place in a 5-week period, which can be a short period, but still significant impacts were detected. The results can be different if applied within longer time periods. The effects can either become weaker or stronger. Considering the developmental periods of students, the longitudinal studies can make more sense. If this is the case, the scaffolding approaches should be adjusted according to the developmental stages of learners. The participants of this study were seventh graders and the assignments were in the format they used to. School context might have influenced the way students perceived and acted, but future research can be designed in different contexts and with different participants. Moreover, the interaction of students during breaks, out-of-school experiences, prerequisites such as computer literacy, and different prior characteristics of students are all threats to this study.

The data gathered in this study included 72 students and there is a gap in the literature focusing on cases individually. As metacognition is a hard phenomenon to explore, smaller samples and closer observations should be included in future studies. This study focused on individual work to monitor metacognitive skill gains. Further studies can integrate metacognitive scaffolds to group works. Dynamics between peers and metacognitive scaffolds can be observed. The WISS tool can be adapted according to the needs of group dynamics and students' characteristics. Rather than providing the same interface and procedures for metacognitive scaffolding for all students, it can be more adaptable based on groups' or individual student's needs, differences, and preferences. Then, the tool's effectiveness can be studied. Even this version of the tool can be compared with the previous tool designed for individual scaffolding. In this way, the researcher might be able to examine the effects either on metacognitive skillfulness or performance. For further studies, more qualitative approaches such as think aloud protocols can help to understand the purposes of actions.

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References

Anderson, L., & Krathwohl, D. A. (2001). *Taxonomy for learning, teaching and assessing: A revision of Bloom's taxonomy of educational objectives*. New York, NY: Longman.

Azevedo, R. (2002). Beyond intelligent tutoring systems: Using computers as metacognitive tools to enhance learning? *Instructional Science*, *30*, 31–45.

Azevedo, R. (2005). Using hypermedia as a metacognitive tool for enhancing student learning? The role of self-regulated learning. *Educational Psychologist*, *40*(4), 199–209.

Azevedo, R., Winters, F. I., & Moos, D. C. (2004). Can students collaboratively use hypermedia to learn about science? the dynamics of self-and other-regulatory processes in the classroom. In: *Proceedings of the 6th International Conference on Learning Sciences*. *International Society of the Learning Sciences*, pp. 50–57.

Brown, A. L. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In F. E. Weinert & R. H. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 65–116). Hillsdale, NJ: Lawrence Erlbaum Associates.

Brown, G. (1984). Metacognition: New insights into old problems? *British Journal of Educational Studies*, *32*(3), 213–219.

Cagiltay, K. (2006). Scaffolding strategies in electronic performance support systems: Types and challenges. *Innovations in Education and Teaching International*, *43*(1), 93–103.

Cary, M., & Reder, L. M. (2002). Metacognition in strategy selection. In *Metacognition* (pp. 63–77). Boston, MA: Springer.

Chen, C.-H. (2014). An adaptive scaffolding e-learning system for middle school students' physics learning. *Australasian Journal of Educational Technology*, *30*(3), 342–355.

Delen, E., Liew, J., & Willson, V. (2014). Effects of interactivity and instructional scaffolding on learning: Self-regulation in online video-based environment. *Computers and Education*, *78*, 312–320.

Devolder, A., Van Braak, J., & Tondeur, J. (2012). Supporting self-regulated learning in computer-based learning environments: Systematic review of effects of scaffolding in the domain of science education. *Journal of Computer Assisted Learning*, *28*(6), 557–573.

Dillon, A., & Gabbard, R. (1998). Hypermedia as an educational technology: A review of the quantitative research literature on learner comprehension, control, and style. *Review of Educational Research*, *68*(3), 322–349.

Feyzi-Behnagh, R., Azevedo, R., Legowski, E., Reitmeyer, K., Tseytlin, E., & Crowley, R. S. (2014). Metacognitive scaffolds improve self-judgments of accuracy in a medical intelligent tutoring system. *Instructional Science*, *42*(2), 159–181.

Flavell, J. H. (1976). Metacognitive aspects of problem solving. In L. B. Resnick (Ed.), *The nature of intelligence* (pp. 231–236). Hillsdale, NJ: Erlbaum

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist*, *34*(10), 906–911.

Garii, B. (2002). *That "aha" experience: Meta-cognition and student understanding of learning and language*. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA. Retrieved from http://eric.ed.gov/PDFS/ED464127.pdf

Graesser, A. C., McNamara, D. S., & VanLehn, K. (2005). Scaffolding deep comprehension strategies through Point&Query, AutoTutor, and iSTART. *Educational Psychologist*, *40*(4), 225–234.

Hannafin, M., Land, S., & Oliver, K. (1999). Open learning environments: Foundations, methods, and models. In C. Reigeluth (Ed.), *Instructional design theories and models* (pp. 115–140). Mahwah, NJ: Lawrence Erlbaum Associates.

Howland, J. L., Jonassen, D., & Marra, R. M. (2012). *Meaningful learning with technology* (4th ed.). Boston, MA: Pearson.

Huertas, A., López, O., & Sanabria, L. (2017). Influence of a metacognitive scaffolding for information search in b-learning courses on learning achievement and its relationship with cognitive and learning style. *Journal of Educational Computing Research*, *55*(2), 147–171.

Jonassen, D. H., Howland, J., Moore, J., Marra, R. M. (2003). *Learning to solve problems with technology: A constructivist perspective* (2nd ed.). Upper Saddle River, NJ: Prentice-Hall.

Jumaat, N. F., & Tasir, Z. (2015, April). Metacognitive scaffolding to support students in learning authoring system subject. In *2015 International Conference on Learning and Teaching in Computing and Engineering*, *Taipei,* (pp. 87–90). Taipei: IEEE.

Kelemen, W. L., Winningham, R. G., & Weaver, C. A., III. (2007). Repeated testing sessions and scholastic aptitude in college students' metacognitive accuracy. *European Journal of Cognitive Psychology*, *19*, 689–717.

Kim, H. J., & Pedersen, S. (2011). Advancing young adolescents' hypothesis-development performance in a computer-supported and problem-based learning environment. *Computers and Education*, *57*, 1780–1789.

Kim, M. C., & Hannafin, M. J. (2010). Scaffolding problem solving in technology enhanced learning environments (TELEs): Bridging research and theory with practice. *Computers and Education*, *56*, 403–417.

Kluwe, R. H. (1982). Cognitive knowledge and executive control. In L.B. Resnick (Ed.), *Human mind-animal mind* (pp. 201–224). New York, NY: Springer.

Lazonder, A. W., & Rouet, J.-F. (2007). Information problem solving instruction: Some cognitive and metacognitive issues. *Computers in Human Behavior*. Advance online publication. doi:10.1016/j.chb.2007.01.025.

Lin, X., Schwartz, D. L., & Hatano, G. (2005). Toward teachers'adaptive metacognition. *Educational Psychologist*, *40*(4), 245–255.

Martinez, M. E. (2006). What is metacognition? *Phi Delta Kappan*, *67*, 696–699.

Mathan, S. A., & Koedinger, K. R. (2005). Fostering the intelligent novice: Learning from errors with metacognitive tutoring. *Educational Psychologist*, *40*(4), 257–265.

McAlpine, L., Weston, C., Beauchamp, C., Wiseman, C., & Beauchamp, J. (1999). Building a metacognitive model of reflection. *Higher Education*, *37*(2), 105–131.

Mohd Rum, S. N., & Ismail, M. A. (2017). Metacognitive support accelerates computer assisted learning for novice programmers. *Educational Technology & Society*, *20*(3), 170–181.

Nelson, T. O., & Narens, L. (1990). Metamemory: A theoretical framework and new findings. *The Psychology of Learning & Motivation*, *26*, 125–141.

Palaigeorgiou, G. E., Despotakis, T. D., Demetriadis, S., & Tsoukalas, I. A. (2006). Synergies and barriers with electronic verbatim notes (eVerNotes): Note taking and report writing with eVerNotes. *Journal of Computer Assisted Learning*, *22*(1), 74–85.

Poitras, E. G., & Lajoie, S. P. (2014). Developing an agent-based adaptive system for scaffolding self-regulated inquiry learning in history education. *ETR&D*, *62*(3), 335–366.

Quintana, C., Zhang, M., & Krajcik, J. (2005). A framework for supporting metacognitive aspects of online inquiry through software-based scaffolding. *Educational Psychologist*, *40*(4), 235–244.

Raes, A., Schellens, T., De Wever, B., & Vanderhoven, E. (2012). Scaffolding information problem solving in web-based collaborative inquiry learning. *Computers and Education*, *59*(1), 82–94.

Rieh, S.-Y., Collins-Thompson, K., Hansen, P., & Lee, H.-J. (2016). Towards searching as a learning process: A review of current perspectives and future directions. *Journal of Information Science*, *42*(1), 19–34.

Sánchez-Alonso, S., & Vovides, Y. (2007). Integration of metacognitive skills in the design of learning objects. *Computers in Human Behavior*, *23*, (2007). 2585–2595.

Selberg, E. W. (1999). *Towards comprehensive web search* (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 9936480).

Sendurur, E., & Yildirim, Z. (2008). Metacognitive Skills Inventory for Internet Search (MSIIS). In J. Luca & E. Weippl (Eds.), *EdMedia: World Conference on Educational Media and Technology* (pp. 4398–4403). Association for the Advancement of Computing in Education (AACE).

Sendurur, E., & Yildirim, Z. (2015). Students' Web search strategies with different task types: An eye-tracking study. *International Journal of Human-Computer Interaction*, *31*(2), 101–111.

Stadtler, M., & Bromme, R. (2008). Effects of the metacognitive computer-tool met.a.ware on the web search of laypersons. *Computers in Human Behavior*, *24*, 716–737.

Tobias, S., & Everson, H. (2002). *Knowing what you know and what you don't: Further research on metacognitive knowledge monitoring*. New York, NY: College Board.

Veenman, M. V. J., & Spaans, M. A. (2005). Relation between intellectual and metacognitive skills: Age and task differences. *Learning and Individual Differences*, *15*(2005), 159–176.

Veenman, M. V. J., Prins, F. J., & Elshout, J. J. (2002). Initial inductive learning in a complex computer simulated environment: The role of metacognitive skills and intellectual ability. *Computers in Human Behavior*, *18*(2002), 327–341.
Walton, M., & Archer, A. (2004). The web and information literacy: Scaffolding the use of web sources in a project-based curriculum. *British Journal of Educational Technology*, *35*(2), 173–186.
Wesiak, G., Steiner, C. M., Moore, A., Dagger, D., Power, G., Berthold, M., . . . Conlan, O. (2014). Iterative augmentation of a medical training simulator: Effects of affective metacognitive scaffolding. *Computers & Education*, *76*, 13–29.
White, B., & Frederiksen, J. (2005). A theoretical framework and approach for fostering metacognitive development. *Educational Psychologist*, *40*(4), 211–223.
Wolf, S. E., Brush, T., & Saye, J. (2003). Using an information problem-solving model as a metacognitive scaffold for multimedia-supported information-based problems. *Journal of Research on Technology in Education*, *35*(3), 321–341.
Wood, D., Bruner, J., & Ross, G. (1976). The role of tutoring and problem solving. *Journal of Child Psychology and Psychiatry*, *17*, 89–100.
Woolfolk, A. (2007). *Educational psychology* (10th ed.). Boston, MA: Pearson Education Inc.
Wu, H.-L., & Pedersen, S. (2011). Integrating computer- and teacher-based scaffolds in science inquiry. *Computers and Education*, *57*, 2352–2363.
Yildirim, Z. (2005). Hypermedia as a cognitive tool: Student teachers' experiences in learning by doing. *Educational Technology & Society*, *8*(2), 107–117.

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