Effect of a Metacognitive Scaffolding on Information Web Search

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Abstract: The objective of the research was to determine the effect that a metacognitive scaffolding for Web information searches exercises on the development of school students, through a general chemistry course in a blended learning modality. One hundred and four students from a school of the city of Bogotá D.C.-Colombia participated in the study. The research followed a quasi-experimental design with a pretest and posttest. Three tenth-grade groups, previously established, worked with a b-learning environment with three versions: the first group worked with a fixed scaffolding, the second with an optional scaffolding, and the third group interacted with a b-learning environment without any type of scaffolding whatsoever. The Metacognitive Awareness Inventory (MAI) test was used to measure metacognitive abilities before and after data treatment. To analyze the data, a Multivariate Analysis of Covariance (MANCOVA) was conducted, which showed that the fixed scaffolding favors the development of metacognitive abilities, especially those related to procedural knowledge, planning, organization, monitoring, and evaluation. This tool, possibly based on the analysis and reflection of their own performance in task development, allowed students to consolidate structured strategies in Web information searches. In contrast, the use of the optional scaffolding did not exhibit the expected results since it was not used by a high percentage of students. These findings, among others, are discussed in the study.

Keywords: Scaffolding, information search, metacognitive ability, b-learning environment, secondary education.

1. Introduction

It is evident that the use of the Internet is becoming increasingly frequent in school environments due to the availability, diversity, and accessibility of information that is found in this communication medium (Marhan, Saucan, Popa and Danciu, 2012; Saito and Miwa, 2007; Spink, Park and Koshman, 2006). In spite of the generalized use of the Internet in the completion of learning tasks, the quality of the assignments submitted by students is not as expected; consequently, the learning outcome derived from this process is not the one desired by teachers (Arango, Bringué and Sádala, 2010; Chli and Wilde, 2006; Li and Lim, 2008; M. Zhang and Quintana, 2012).

This issue could indicate that students neither perform effective information web searches, nor do they engage in a reflection process about their own knowledge construction based on the searches conducted through this medium (Sun, Ye, and Hsieh, 2014). Regarding this question, some authors assert there are three possible causes why students do not perform effective information Web searches: one refers to the poor efforts made to read and understand the results of their searches, limiting themselves to only copying and pasting the information found (Li and Lim, 2008; Wallace, Kupperman and Krajcik, 2000).

A second reason relates to how easily students become disoriented on the Web due to the large quantity of information available therein (Dias, Gomes and Correia, 1999) and, finally, one related to lacking the skills to monitor, evaluate, and regulate online information search (Quintana, Zhang and Krajcik, 2005; M. Zhang and Quintana, 2012; W. Zhang, Hsu, Wang and Ho, 2015).

In view of this problem, the community of information technologies applied to education proposes, designs, and validates scaffoldings aimed at favoring subjects' performance when autonomously engaging in learning tasks in Web environments and, thus, facilitate the acquisition of information search skills, improve learning processes, and propose strategies for the development of metacognitive abilities, among others (Molenaar, Van-Boxtel and Sleegers, 2010; Quintana et al., 2005; Valencia-Vallejo, López-Vargas and Sanabria-Rodríguez, 2018; Zhang and Quintana, 2012; Zohar and Barzilai, 2013).

In this field of work, different researchers have designed and implemented, in computational scenarios, fixed and optional scaffoldings to support students in task development. Fixed scaffoldings permanently support the

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student through a series of pop-up messages, which are oriented toward guiding and focusing task development. The messages are always shown intentionally so that in this way, the student always takes them into account during the progress of the learning activity (Kim and Hannafin, 2011). To this extent, when the support is constant or fixed, the development of different students' cognitive abilities is positively affected (Chang, Sung and Chen, 2002; Lee and Songer, 2004; Greene and Azevedo, 2009; Wang and Lin, 2007; Wecker, Kollar, Fischer and Prechtl's, 2010).

On the other hand, optional scaffoldings are available in the computational scenario as a "help tool". The novice is informed about said tools and he decides when to use it (Lakkala, Muukkonen and Hakkarainen, 2005). In that regard, Cagiltay (2006) proposes it be the student who decides whether to use or not to use the scaffolding in task development, obeying their individual differences and learning needs. In accordance to the foregoing, it is evident that not all students require the same type and intensity of the support through the scaffolding. In addition, it is feasible that these aids fade over time as the student acquires the skills and abilities developed with these pedagogic and/or didactic tools.

From this discussion, it is possible to identify a contradiction between the benefits that may result from the use of fixed or optional scaffoldings, when students individually learn in computer-based learning environments. For this reason, it is necessary to conduct other studies aimed at understanding and explaining what is the most effective manner of supporting students when interacting with this type of scenarios (Chang, Sung and Chen, 2002; Lakkala et al., 2005). Taking into account this issue, the following research question is posited:

What is the effect generated by a b-learning environment that contains within its structure a fixed scaffolding or, an optional scaffolding, and another, without any type of scaffolding whatsoever, on the development of cognitive abilities in high school students when they perform Web information searches?

The foregoing research questions posits as the hypothesis of interest in the present study, if the use of a metacognitive scaffolding of an optional type for a Web information search, available in a b-learning environment, significantly favors the development of metacognitive abilities in comparison to those students that use a fixed scaffolding in the same b-learning environment.

2. Literature Review

2.1 Metacognition in Learning

Flavell (1979) coined the term of metacognition and defines it as the knowledge that a person has about his or her own cognitive processes and the control they can exercise on these. It refers to the ability that individuals have to manage and regulate their own learning processes. Research findings in the educational context systematically show that individuals that deploy metacognitive abilities have high probabilities of reaching the learning goals and improving their academic performance, in comparison to those that exhibit a deficit in this type of abilities (Hacker, Dunlosky, and Graesser, 2009). Similarly, findings indicate that metacognition is a strong predictor of novices' academic performance (Bromme, Pieschl and Stahl, 2010; Desoete, Roeyers and De Clercq, 2003; Hacker et al., 2009; Thiede, Anderson and Therriault, 2003).

In general, a novice that possesses metacognitive abilities in their own learning process may be defined as a student that is able to formulate concrete learning goals for themselves, plan activities to reach them, systematically monitor their performance during the execution of said activities, continuously self-evaluate themselves according to the set goals, make the necessary adjustments as a function of the goal, and finally, assess the result of their learning (Pintrich, 2004; Zimmerman, 1986).

2.2 Metacognitive Scaffoldings

The concept of scaffolding was defined based on the Zone of Proximal Development (ZPD) posited by Vygotsky, in his sociocultural theory of learning and it refers to the assistance an adult can provide a child with the purpose of fulfilling the latter's learning objectives (Tuckman, 2007; Wood, Bruner and Ross, 1976; Wu and Pedersen, 2011). A scaffolding is a type of aid that is provided to the student to successfully develop a learning task (Wood et al., 1976). Metacognitive scaffoldings favor planning, monitoring, self-evaluation, and control of cognitive processes, in a conscientious manner, during the development of learning tasks in computational environments (Kim and Hannafin, 2011; López-Vargas, Ibáñez-Ibáñez and Racines-Prada, 2017; Zhang and Quintana, 2012).

In that regard, Quintana et al. (2005) and Molenaar et al. (2010) state that metacognitive scaffoldings are characterized by managing and regulating cognitive processes. This type of scaffoldings helps the student: (1) plan what they want to learn; in other words, it proposes defining learning goals and planning the necessary activities to achieve them, (2) execute and monitor the progress in the proposed goals and activities, and (3) evaluate the results obtained with the purpose of reviewing the planning and adjusting the strategies to achieve the learning goals. This process lets the student gain knowledge on their way of learning and, in this sense, it allows them to make decisions on choosing the most effective and efficient strategies to achieve the desired learning, among others (Azevedo, 2005; Hederich-Martinez, López-Vargas and Camargo-Uribe, 2016; Molenaar et. al., 2010; Quintana et al., 2005).

Among metacognitive scaffoldings, those of a fixed-type are proposed, which offer the student permanent support during task development. This scaffolding is intentional and evident within the computer-based learning environment. It is displayed in the form of pop-up windows directed toward guiding task development and is characterized by always being present in the computational environment, independent of students' learning characteristics and needs (Kim and Hannafin, 2011).

In contrast to the fixed scaffoldings, are the optional scaffoldings, which are characterized by being available in the computational environment in the form of help tools, on which students have been previously informed so that they use them according to their learning needs. These tools have the capability of respecting individual differences and in theory, they empower the student so that they decide when to use them or not (Cagiltay, 2006; Lakkala et al., 2005).

There is no consensus among the academic community regarding the use of scaffoldings of a fixed or optional-type, providing contradictory results in the studies. Some assert that fixed scaffoldings favor to a greater extent the development of different cognitive abilities in students; while others, report that optional scaffoldings may be ignored by students in some cases and, thus, they do not achieve the desired learning (Chang et al., 2002; Lakkala et al., 2005). Other investigations show that fixed scaffoldings do not significantly benefit the development of desired cognitive abilities (Renkl and Atkinson, 2003).

Faced with the contradictory results on the effectiveness of fixed and optional scaffoldings, it is necessary to investigate, in greater depth, the use of these two types of scaffoldings when they support students in achieving different cognitive abilities.

Regarding the foregoing, different studies propose the use of metacognitive scaffoldings to support students in the classroom when interacting in computational scenarios. Li and Lim (2008) researched the impact of two types of scaffoldings: one fixed and the other adaptive, which provided support to students when they performed information Web searches. The study was conducted with seventh-grade students.

In the fixed scaffolding, novices used a template that guided the information search. It contained explicit instructions to perform searches. The template allowed the student to choose the search topic through keywords. Similarly, it offered appropriate search engines to perform the search; thus, it got the student to provide an answer to the assigned task. On the contrary, in the adaptive scaffolding, the search was guided by an expert teacher who allowed the students to work in pairs to solve the task. The obtained results showed that the fixed scaffolding offered better results in the development of information search tasks than the adaptive scaffolding since working in pairs hindered the structured synthesis of information.

In another study, Zhang and Quintana (2012) designed and validated a metacognitive scaffolding of a fixed-type, with the purpose of supporting information Web search processes. The scaffolding was tested with 16 sixth-grade students, which were divided into two groups. The first group performed information searches with the help of the scaffolding independently and the second group searched for information on the Internet in the traditional manner without teacher supervision. The results of the implementation were gathered through videos and conversations between students. Based on these evidences, it was concluded that the use of scaffoldings improved the efficacy of information Web searches since students easily saved and recovered information, systematically conducted their searches, and focused their attention on task development;

situation that probably allowed avoiding distractors and developed their metacognitive abilities (Zhang and Quintana, 2012). (Graesser et al., 2007)

Regarding critical thinking, studies exist that show the impact of scaffoldings on critical views and metacognitive abilities. For example, Graesser, Wiley, Goldman, O'Reilly, Jeon, and McDaniel (2007) researched the impact of a Web tutor called SEEK on the development of critical views through planning, monitoring, and reflection in university students. Students had to explore different Web pages in order to inquire the causes of a volcanic eruption during approximately two hours of work. The study's results did not have a positive impact on the development of critical thinking or on planning, monitoring, and reflection. Researchers concluded that due to the short interaction time with the Internet, the desired results were probably not found; therefore, they propose improving the scaffolding in terms of training, quality, and interaction quantity; thus, evidencing significant changes related to the development of critical views in students in science-specific subjects.

In a more recent study, Kuo, Chen, and Hwang (2014) designed a fixed computational scaffolding called Meta-Analyzer. It implemented an information Web search strategy. Eighty university students, which were randomly assigned to one experimental and another control group, participated in the study. The experimental group searched for information with the support of the scaffolding and the control group searched content in a conventional manner. Based on the results, it was possible to establish that the experimental group students exhibited better performances in task achievement, while at the same time developing structured abilities to perform Web searches, in comparison to the control group. According to the study, novices that interacted with Meta-Analyzer developed critical thinking abilities. (Kuo, Chen and Hwang, 2014)

In sum, the presented studies allow concluding that the design of metacognitive scaffoldings for information Web searches constitute a research field worthy of being studied in-depth since they are considered as a possible alternative when supporting information search processes in students with different schooling levels (Kuo et al., 2014; Lee, 2005).

3. Method

3.1 Design

The research follows a quasi-experimental design with three groups of tenth-grade students, previously established, from a private school of Bogotá D.C. – Colombia. As the study's independent variable, is a b-earning environment with three values: one group that interacted with a b-learning environment that included a fixed Metacognitive Scaffolding for Information Search (MSIS), another group worked with the b-learning environment, where MSIS use was optional, and a third group that interacted with the b-learning environment without any type of scaffolding whatsoever.

The study's dependent variable was the development of metacognitive abilities, which has two values: 1) metacognitive knowledge (declarative knowledge, procedural knowledge, and conditional knowledge) and 2) metacognitive regulation (planning, organization, monitoring, control, and evaluation). As co-variable, is the metacognitive ability pretest. The research's data were analyzed through a MANCOVA and a Bonferroni contrast. Both tests were performed through the Statistical Package for the Social Science (SPSS) 20.0 software.

3.2 Participants

The research was conducted with a sample of 104 students (61 women and 43 men) from the tenth grade of a private school of the city of Bogotá D.C., located in the locality of Engativá. The ages ranged between 13 and 17 years (Mean=15.11 years, Standard Deviation=0.72). The number of students in each one of the tenth-grade courses is shown in table 1.

Table 1: Number of students that participated in each one of the courses

Scaffolding (MSIS)	Number of students
Fixed Scaffolding	40
Optional Scaffolding	34
Without Scaffolding	30
Total	104

3.3 Instruments

3.3.1 Metacognitive Awareness Inventory (MAI)

To determine students' metacognitive abilities, a MAI test was employed (Schraw and Moshman, 1995). The instrument allows identifying subjects' metacognitive abilities through 52 items, distributed in two components, namely: metacognitive knowledge and metacognitive regulation.

Metacognitive knowledge refers to the knowledge that a subject has on his or her own knowledge. This component has three subcategories: declarative knowledge, procedural knowledge, and conditional knowledge. On the other hand, the second component, that is to say, metacognitive regulation, refers to the activities that allow controlling learning. It has five subcategories: planning, organization, monitoring, control, and evaluation.

Planning relates learning goal and necessary resource assignment as a function of the desired goal. On the other hand, organizing considers the abilities and strategies that a person uses efficiently when developing learning tasks. Regarding monitoring, this refers to the level of supervision that the novice performs on their learning process or, of the strategies used during task development. Control has to do with the process through which the subject identifies learning weaknesses and adjusts the strategies to improve their performance and the effectiveness of the strategies implemented after a lesson.

MAI is a self-report questionnaire with a Likert scale using the following statements: 1. Strongly disagree, 2. Disagree, 3. Neither agree nor disagree, 4. Agree, and 5. Strongly agree. This instrument is validated in the Spanish language with Colombian students and evidences a good level of internal consistency, with a Cronbach's alpha =0.94. (Huertas, Vesga, and Galindo, 2014). In the present research the instrument had a Cronbach's alpha =0.90.

3.3.2 Metacognitive Scaffolding for Information Search (MSIS)

MSIS was developed in Hypertext Preprocessor (PHP) 5.3.26 language, it used a MySQL 5.5.37 database, and it was installed in a Web Apache 2.2.25 server. The interface was elaborated with HTML5, CSS3, and Jquery. The video aids were created in mp4 format, characteristics that allow the tool to adapt to virtual learning environments like Moodle. The scaffolding's architecture was built based on the elements proposed by Hadwin and Winne, in their self-regulation learning model, which has a high metacognitive component (Hadwin and Winne, 2001) .

The scaffolding was designed and implemented within the structure of a hypermedia scenario, which was used in the blended learning modality. In other words, it combined the student's autonomous work outside of the classroom and face-to-face classes. This modality is a hybrid educational system, in other words, it combines aspects of face-to-face education and information technologies-based instruction (Chafiq et al., 2014; Köse, 2010; Pektaş and Gürel, 2014). The hypermedia environment contains theoretical elements, examples, and exercises on general chemistry. Additionally, it has technological resources, such as: videos, animations, and photographs, among others. The software consists of eight learning modules and was built in the Moodle platform.

MSIS's objective is to offer support to students that perform information Web searches. Following this line of thought, the scaffolding has structured guidelines based on metacognition for the development of search tasks (Hadwin and Winne, 2001; Kim and Hannafin, 2011). The different stages that make up the metacognitive scaffolding are described below.

Stage 1. Knowledge Judgments: In this stage, the scaffolding introduces the student to the information Web search task with the purpose of getting them to reflect on and A their prior knowledge on the topic of query (declarative, procedural, and conditional knowledge). Similarly, it performs a detailed description of the stages of the information search process, which correspond to planning, execution, and evaluation (figure 1) (Kwon, Hong and Laffey, 2013; Li and Lim, 2008). This information allows the student to reflect on the state of their current knowledge and prepares them for the next stage.

Figure 1: Reflection and knowledge judgment stage

Stage 2. Search Planning: During this stage, the novice designs a work plan for the information Web search based on the following aspects: choosing a learning goal that guides their actions and acts as a reference point. Time spent on the information search process, for which the scaffolding offers the student four options: one of 30 minutes, others of 60, 90, and 120 minutes. It also questions them on their prior knowledge of the subject of the search task, for which the student is requested to indicate on a scale their level of knowledge.

On the other hand, the scaffolding offers the student five keywords on the search subject and presents them with three options to perform the information query. These options are: search engines (Google, Bing, and Yahoo), Web pages (Online teacher, Biology hypertexts, and Icaro), and finally, open access databases (Network of Scientific Journals of Latin America and the Caribbean-Redalyc and Directory of Open Access Journals-DOAJ) (Yelland and Masters, 2007; M. Zhang and Quintana, 2012).

To promote metacognitive monitoring in this stage, the section called "Thinking about my planning" was designed. There, the scaffolding, presents a synthesis of the planning and requests the novice to indicate if they agree with or want to modify the established items. This situation leads the student to reflect on the planning done.

As observed, planning has the objective of preparing the student, conscientiously, for the development of the information search task in an organized and structured fashion and, at the same time, it favors the capacity of monitoring, evaluating, and controlling the aspects proposed in this stage. Once this process has been completed, the student must face the next stage, which corresponds to search execution (Kim and Hannafin, 2011; Molenaar et al., 2010; Poitras, Lajoi, and Hong, 2012) (figure 2).

Stage 3. Search Execution: This stage begins with the information search of the chosen sites (search engines, Web pages, and databases) (Stronge, Rogers and Fisk, 2006; Thatcher, 2006). The scaffolding requests the novice to choose three reliable pages in accordance with the information search objective. If the pages contain the desired information, the scaffolding saves the Uniform Resource Locator (URL). Otherwise, it indicates that they must consult a new source of information. This aspect corresponds to the actions of monitoring and control that the scaffolding offers the novice with the objective of creating, in them, attitudes of reflection and control regarding their actions (figure 3).

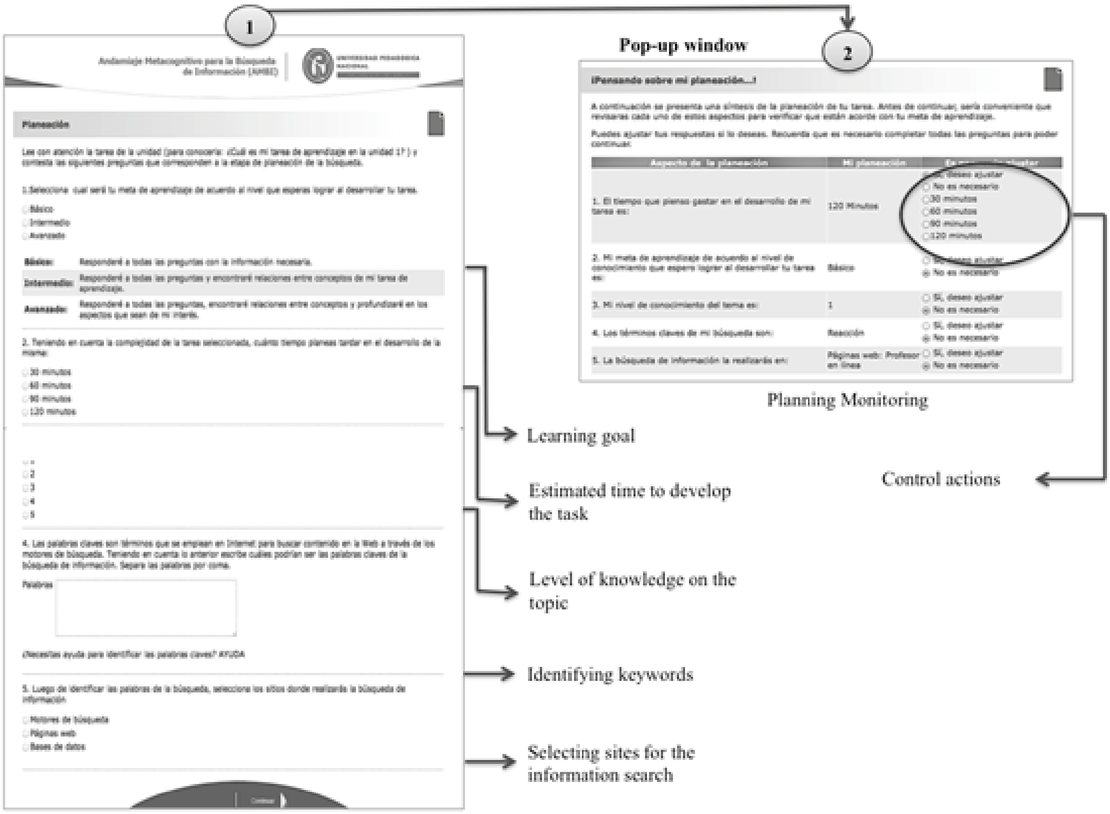

Figure 2: Planning of and reflection on the information Web search

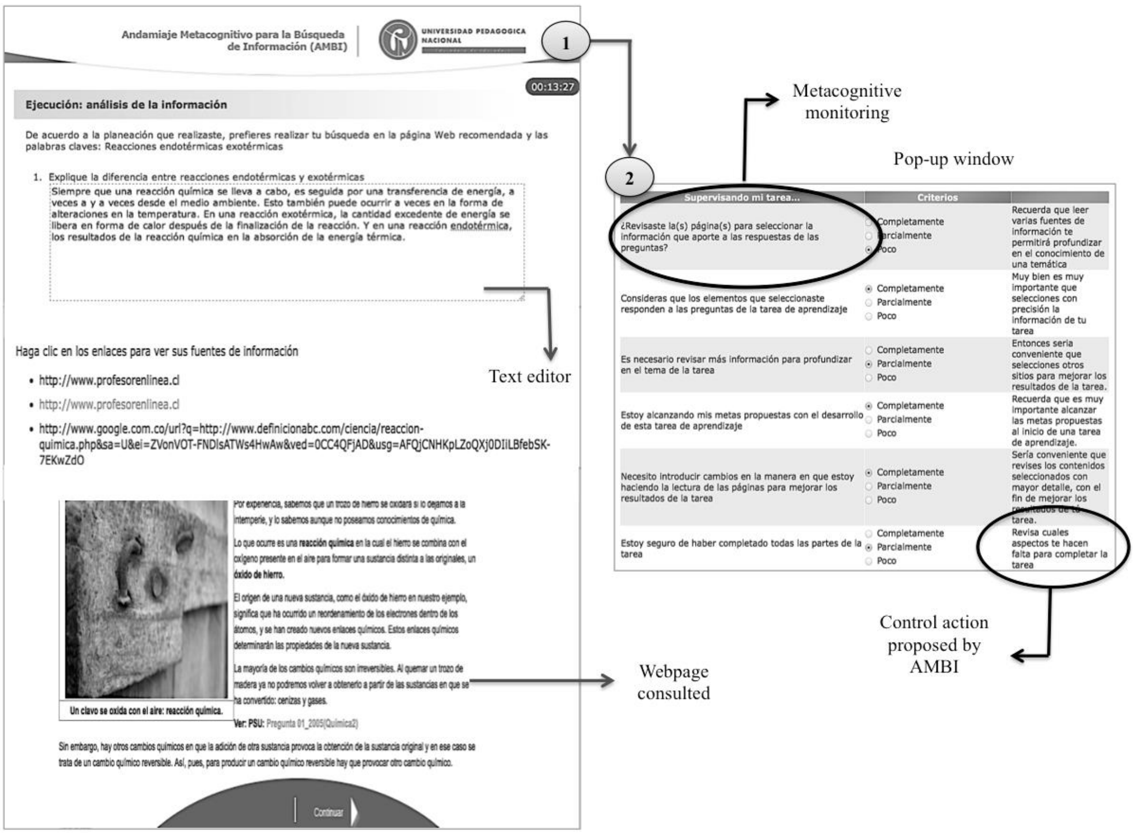

Figure 3: Information search planning

Once the process of choosing the search sites has been completed, the student analyzes and synthesizes the information found in order to answer the task (Mannheimer, 2010; M. Zhang and Quintana, 2012). This information search stage has a text editor for the student to synthesize the selected content and answer the search task.

At the end of the synthesis of information, the scaffolding offers the student the possibility of performing metacognitive monitoring of the completed activity through the section “Supervising my learning task”, which has the objective of identifying the level of comprehension and depth reached in the revised content. If the student considers that they did not achieve the purpose, they can perform a new information Web search in order to reach a greater level of comprehension of the concepts studied (figure 4).

Finally, the scaffolding presents a series of metacognitive questions, which must be evaluated based on an established scale. According to the score obtained, the scaffolding offers feedback and proposes control actions, such as: improve the answer’s wording, elaborate on and complement the task’s answers, employ resources such as drawings or graphs that improve subject matter comprehension as a function of the achievement of learning goals (Fund, 2007; Scherer and Tiemann, 2012).

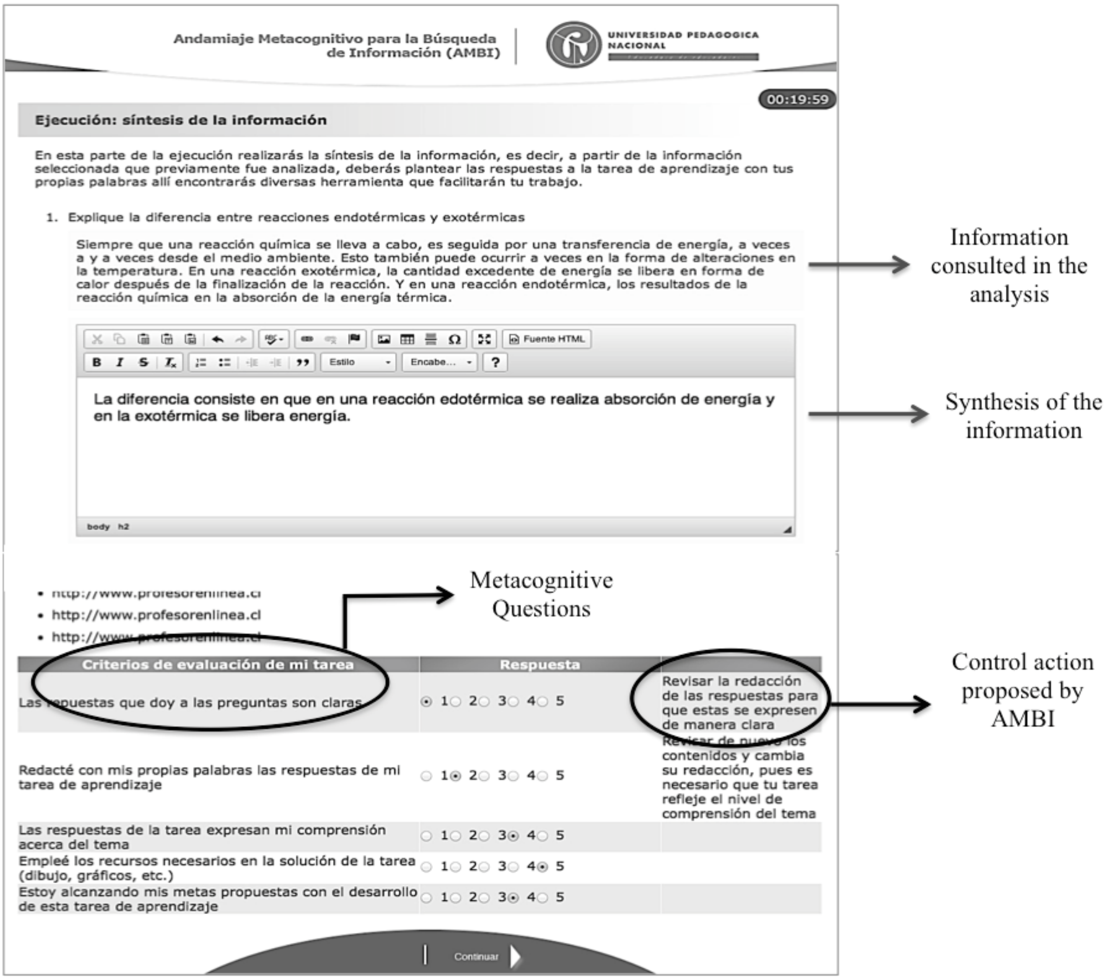

Figure 4: Synthesis of selected content

Stage 4. Evaluation of Search Results: this stage has the intent of getting the student to reflect on the progress so far in answering the learning task. In this sense, the student is forced to reflect on the achievement of the learning goal according to their expectations. Similarly, they evaluate if the time established to perform the search was enough; finally, they question if the selected strategy for the information search was effective (see figure 5).

Likewise, in this stage the MSIS allows the student to download the learning task and send it to the teacher for their corresponding evaluation. Once the teacher has revised the task, the feedback and observations are sent to the student's email so that they take actions guided towards improving the next information search.

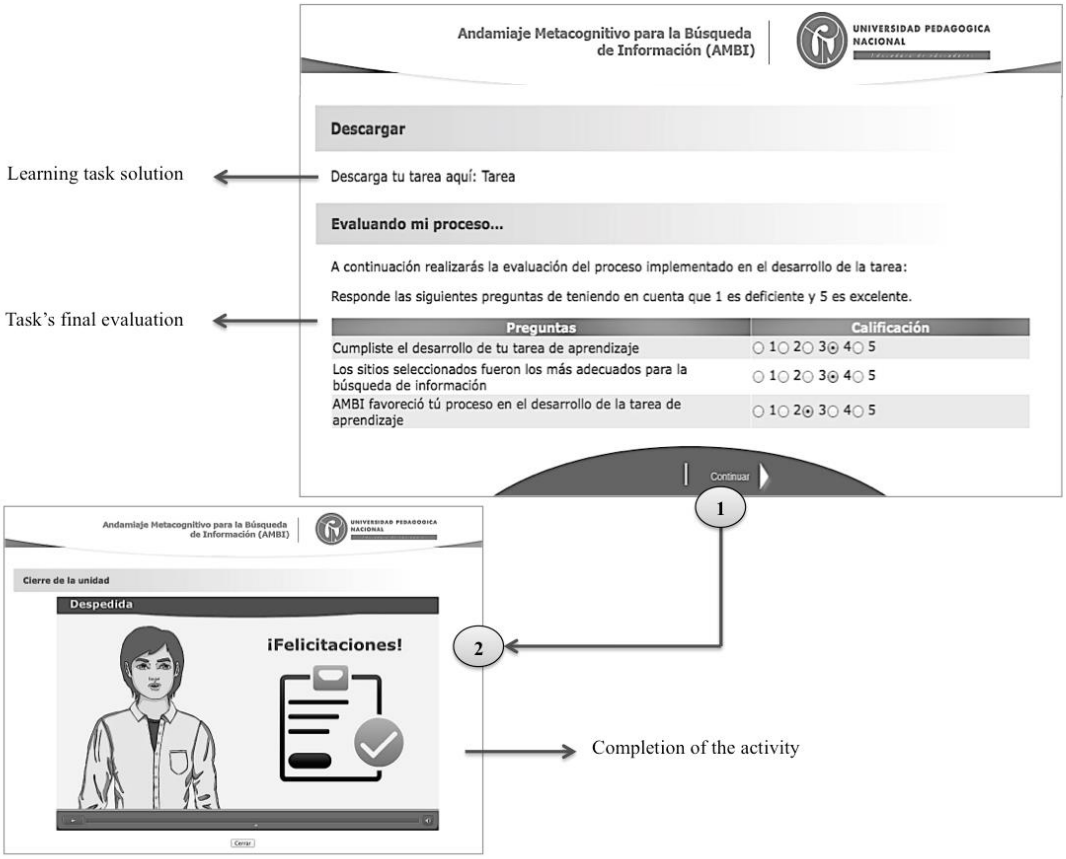

Figure 5: Evaluation of Search Results

3.4 Procedure

For the development of the study, the school's board was contacted and after presenting them with the project, they allowed the implementation of the research with the tenth-grade students. Subsequently, students were invited to participate in the study by explaining the study's benefits in terms of desired learning, situation that resulted in students' acceptance; in addition, parents were requested to authorize their children's participation in the study, informing them, at the same time, that the results would be managed confidentially and were for research purposes.

Before the start of the study, users and passwords were created so that students could access the Moodle platform. While conducting the research, weekly face-to-face meetings were carried out with the novices and teachers during chemistry period.

During the face-to-face classes, the teacher explained to students conceptual aspects of the different chemistry topics through examples and exercises. In these sessions, students browsed through the scenario implemented on the Web. At the end of the class, the teacher assigns the task to be completed by the students, which should be completed through information Web search. This task was worked on during out-of-class schedules and was available on the Moodle platform. Tasks completed by the students were sent weekly to the teacher through the same platform.

Once the teacher received the task, its corresponding evaluation was conducted and feedback was provided through each student's email. Similarly, in the next class, the teacher made observations according to student's answers. The completion of each one of the eight learning modules followed the same procedure.

To monitor the study, a private domain was acquired (http://aulavirtual.adrianahuertas.co), which was used by students during the academic semester. The Moodle platform contained three courses in which the students enrolled. Each course presented the same educational resources, but differed in the scaffolding to be used. To that effect, a group of students had a fixed-type scaffolding, which was permanently showed to students through the platform and during the Web information search. Another group had an optional scaffolding, which was presented as a "help" option in the platform during the information search, and students could choose whether to use it or not. A third group corresponded to the control group, which did not use MSIS.

4. Findings

A MANCOVA was applied to the results obtained from the research. From this analysis, it was established that in the category of metacognition knowledge the resulting models have a high level of prediction of the different observed variables. The model explains a 68.3% of the variance in "declarative knowledge". It is followed by the "procedural knowledge" variable, with a 57.3% of the total variance. Lastly, is found "conditional knowledge" with a 57.1% of the total variance.

The results show that the declarative knowledge co-variable (pretest) has a significant association only with declarative knowledge (posttest); ($F(1,98)$ = 120.05; $p\leq$ 0.001; η_2=0.551). The procedural knowledge co-variable (pretest) has a statistically significant effect on procedural knowledge (posttest); ($F(1,98)$ = 55.65; $p\leq$ 0.001; η_2=0.362). The conditional knowledge co-variable (pretest) has an effect on procedural knowledge (posttest); ($F(1,98)$ = 75.38; $p\leq$ 0.001; η_2=0.435). Finally, it can be observed that the independent variable MSIS has a significant effect only on procedural knowledge ($F(2,98)$ = 3.22; p=0.044; η_2=0.062).

Regarding the resulting models in the metacognitive regulation category, the variable that has greater variance explained is "planning", which achieves predicting 82.9%. In second place, "monitoring", with a 77.0% of the total variance. In third place, "organization", with a 74.4% of the total variance. In fourth place, "evaluation", with a 73.3% of the total variance. Lastly, "control" with a 68.7% of the total variance.

The results of the metacognitive regulation category show that all the co-variables exhibit significant associations with the final state of the same variable. Regarding the independent variable MSIS, it could be established that it has a significant effect on planning ($F(2,96)$ = 30.04; $p\leq$ 0.001; η_2 =0.385), organization ($F(2.96)$ = 13.17; $p\leq$ 0.001; η_2=0.215), monitoring ($F(2,96)$ = 8.81; $p\leq$ 0.001; η_2=0.155), and evaluation ($F(2.96)$ = 14.68; $p\leq$ 0.001; η_2=0.234).

The results of the MANCOVA analysis are shown in figure 6, where it can be observed that the independent variable MSIS has a significant statistical effect on the development of subjects' metacognitive abilities in five categories of the MAI instrument (procedural knowledge, planning, organization, monitoring, and evaluation).

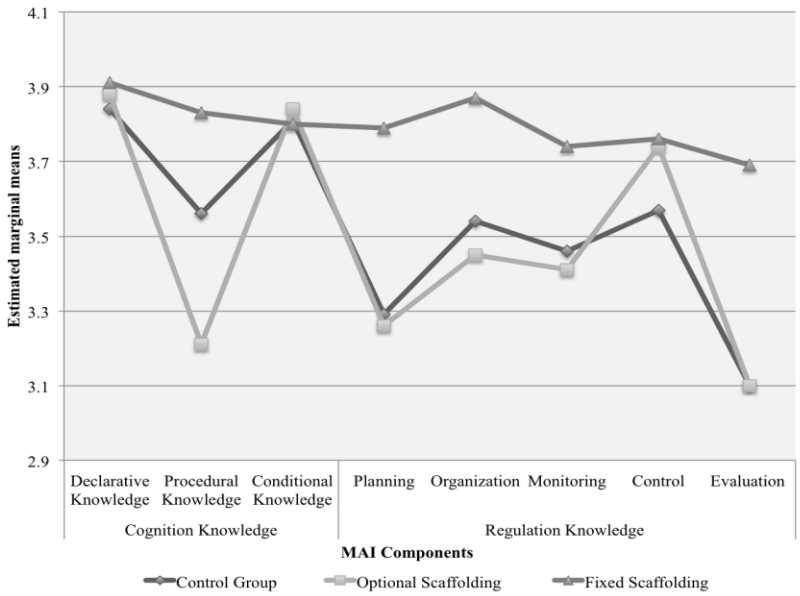

Figure 6: Estimated marginal means for the work with MSIS and the control group

It can be appreciated that the students that used the fixed scaffolding as support to answer their information search tasks obtained better results in the MAI test than the students that used the optional scaffolding and the students that did not have MSIS.

With the purpose of exploring, in greater detail, the relationship of the scaffolding with the development of metacognitive abilities in students, a complementary analysis through a Bonferroni contrast was conducted (Table 2).

Table 2: Procedural Knowledge Bonferroni Contrast

Dependent Variable	(I) MSIS	(J) MSIS	Mean Difference (I-J)	Std. Error	*Sig.*	95% Confidence Level for the difference	
						Lower Bound	Upper Bound
Post Procedural Knowledge	Optional Scaffolding	Control Group	-0.04	0.13	1	-0.36	0.28
		With Fixed Scaffolding	-.31*	0.12	0.058	-0.61	0
	Control Group	Optional Scaffolding	0.04	0.13	1	-0.28	0.36
		With Fixed Scaffolding	-0.26	0.13	0.18	-0.59	0.06
	With Fixed Scaffolding	Optional Scaffolding	.31*	0.12	0.058	0	0.61
		Control Group	0.26	0.13	0.18	-0.06	0.59

In Table 2, the results of the Bonferroni contrast test evidenced that significant differences exist in procedural knowledge between students that interacted with the fixed and optional scaffolding. Similarly, it evidenced that no significant differences exist between the control group and the group that optionally used MSIS. In other words, these two groups are equivalent in the results with respect to procedural knowledge.

Table 3 presents the Bonferroni contrast with respect to metacognitive regulation. The test establishes significant differences in the following subcategories: planning, organization, monitoring, and evaluation between students that interacted with the fixed and optional scaffolding and between those that searched for information with help of the fixed scaffolding and the control group ($p<0.05$). There were no significant differences between the control group and the group that worked with the optional scaffolding.

Table 3: Metacognitive Regulation Bonferroni Contrast

Dependent Variable	(I) MSIS	(J) MSIS	Mean Difference (I-J)	Std. Error	Sig.	95 % Confidence level for the difference	
						Lower Bound	Upper Bound
Post Planning	Optional Scaffolding	Control Group	-.04	.09	1.000	-.26	.18
		Fixed Scaffolding	-.54*	.08	.000	-.73	-.35
	Control Group	Optional Scaffolding	.04	.09	1.000	-.18	.26
		Fixed Scaffolding	-.50*	.09	.000	-.71	-.29
	Fixed Scaffolding	Optional Scaffolding	.54*	.08	.000	.35	.73
		Control Group	.50*	.09	.000	.29	.71
Post Organization	Optional Scaffolding	Control Group	-.09	.09	1.000	-.33	.15
		Fixed Scaffolding	-.42*	.09	.000	-.62	-.21
	Control Group	Optional Scaffolding	.09	.09	1.000	-.15	.33
		Fixed Scaffolding	-.33*	.09	.003	-.56	-.09

Dependent Variable	(I) MSIS	(J) MSIS	Mean Difference (I-J)	Std. Error	Sig.	95 % Confidence level for the difference	
						Lower Bound	Upper Bound
	Fixed Scaffolding	Optional Scaffolding	.42*	.09	.000	.21	.62
		Control Group	.33*	.09	.003	.09	.56
Post Monitoring	Optional Scaffolding	Control Group	-.05	.09	1.000	-.29	.19
		Fixed Scaffolding	-.33*	.084	.000	-.53	-.12
	Control Group	Optional Scaffolding	.05	.09	1.000	-.19	.29
		Fixed Scaffolding	-.28*	.09	.012	-.51	-.05
	Fixed Scaffolding	Optional Scaffolding	.33*	.08	.000	.12	.53
		Control Group	.28*	.09	.012	.05	.51
Evaluation	Optional Scaffolding	Control Group	-.07	.13	1.000	-.38	.24
		Fixed Scaffolding	-.55*	.11	.000	-.81	-.28
	Control Group	Optional Scaffolding	.07	.13	1.000	-.24	.37
		Fixed Scaffolding	-.48*	.12	.001	-.78	-.18
	Fixed Scaffolding	Optional Scaffolding	.55*	.11	.000	.28	.81
		Control Group	.48*	.12	.001	.18	.78

5. Discussion and Conclusions

It can be concluded from the research conducted that the implementation of MSIS, in the fixed version, within a course carried out in the blended learning modality to teach chemistry to tenth grade students, favors the development of metacognitive abilities when they perform information Web search processes. The results were contrary to that expected, insofar as the hypothesis posited was that the students that interacted with the version of the optional scaffolding would have significantly higher results in the development of metacognitive capacity than those who interacted with the version of the fixed scaffolding. The findings by components and categories according to the MAI test are described below.

With respect to cognition knowledge, the results allow establishing that students improved their performances in the procedural knowledge category. That is to say, they developed the capacity of establishing a sequence of structured steps to perform information Web searches. This situation favored the effective search of content to answer learning tasks. In this sense, the use of MSIS, in the fixed condition, allowed students to consolidate structured strategies to perform information Web searches.

However, in the declarative and conditional knowledge categories, the use of MSIS, both fixed and optional-type, regarding the control group, did not exhibit statistically significant differences. This, probably, because the metacognitive scaffolding had a clear intent to induce the novice to the strategy of how to implement a structured information Web search and not of guiding him in a process that favored declarative and conditional knowledge.

This leads to the conclusion that, probably, to improve declarative knowledge in the student, it is necessary to make technical improvements to the MSIS scaffolding. Improvements oriented towards providing the novice with tools that make it easier for them to identify their strengths and weaknesses with respect to the necessary abilities to process information and search for social, time, and space resources required when facing learning tasks that imply information web searches. Including these variables in MSIS would probably lead the student to get to know him or herself better and to be realistic about their expectations.

On the other hand, it is necessary to make technical improvements to MSIS in order to support and favor conditional knowledge. This, insofar, if the scaffolding offered a flexible structure to present different information search strategies to the student, they would probably be capable of making decisions on when and why to use one or another strategy. This suggests that the MSIS scaffolding must incorporate different components to favor all the metacognitive knowledge categories.

With regards to metacognitive regulation, the use of MSIS involved significant differences in the planning, organization, monitoring, and evaluation categories. With respect to planning, it is possible to infer that the students that interacted with MSIS, in the fixed version, where more precise when establishing learning goals, proposed times for the development of the information searches, the use of keywords, and document selection to answer the tasks. Probably, the fact of planning the activities prior to performing the information Web searches, in each one of the eight learning modules, favored the development of this capacity; essential element of metacognition.

Regarding organization, it is possible to deduce that the students that used the MSIS, in the fixed version, developed efficient strategies to perform the information Web search tasks. The scaffolding allowed the students to systematically and in an organized fashion select the search sites (search engines, recommended pages, and databases), establish keywords, and the manner how to analyze and synthesize the information for the development of the learning task.

Similarly, MSIS allowed students to monitor the progress of the different activities during the information search process in order to develop their capacity to supervise their own learning process. This process was achieved through pop-up windows, which presented a summary of the decisions taken and reflection after each completed activity. Possibly, this offered feedback favored the self-observation process during task development.

With respect to the evaluation process, it is possible to establish that the MSIS scaffolding, in the fixed version, showed a positive impact since, in the final reflection stage of each one of the learning modules, the novice was questioned about the task's quality, the activity planning, the time employed, and the goal achievement. The scaffolding allowed the students to conduct an analysis of the performance and effectiveness of the implemented strategy. In general terms, it is possible to assert that the results obtained in this study are consistent with previous research, which discuss that fixed scaffoldings can favor, to a greater extent, students' metacognitive capacity (Huertas, Vesga, Vergara and Romero, 2015; Li and Lim, 2008; M. Zhang and Quintana, 2012).

It is noteworthy, on the other hand, that the control category did not show significant changes when adjusting or changing the strategies chosen for the information Web search. In view of this fact, it is possible to assert that in spite of the students systematically monitoring their information search process in the task development, they were incapable of taking concrete actions to change or adjust those strategies, which were not in accordance with the expected results.

In light of this aspect, the scaffolding requires technical improvements oriented towards including in the MSIS tools that allow students to make the necessary adjustments when establishing the strategies to improve their performance, as a function of the goals reached. This improvement must be articulated with the aforementioned cited. This would probably help the student take concrete control actions regarding the information search process.

From the research conducted, it was expected to find that students that interacted with the optional scaffolding version would exhibit a higher level of development in metacognitive abilities than those obtained by the students in the fixed version. These results concur with the findings of Chang et al., 2002 and Lakkala et al., 2005, who found that students sometimes ignore optional scaffoldings. In this sense, the behavior of the students from the group that had the option of using MSIS was similar to the control group. It was evident that this group used the scaffolding in a low percentage, in spite of the knowledge they had of its existence and advantages. The data show that its use did not exceed 23.52% in each one of the courses' unit lessons. Students were expected to decide, by their own initiative, to use the scaffolding differentially, which is to say, that it be used to fit their learning needs.

According to the results obtained, it is possible to assert that the MSIS scaffolding effectively guided the student in the information search for its subsequent analysis. With this type of aid, the novice had to answer their learning tasks in a structured manner, avoiding copying and pasting the information viewed on the Web. Similarly, the scaffolding reduces the problem of disorientation that students may experience when browsing the Web by avoiding distractions or ineffective searches.

It would be convenient that in future applications, the scaffolding, in a first stage, be fixed so that the student familiarizes themselves with its advantages. Next, in the remaining modules, it is suggested that the scaffolding be optional; thus, the student has the capacity to decide whether to use it, or not, in their information Web searches. Possibly, the results could vary. This suggests that different experiments should be conducted with the optional scaffolding versions in order to obtain greater comprehension on their use and implementation since not all students need the same type of support during the different unit lessons. When the scaffolding is implemented in the same manner for all students, students' differences and individual learning needs are not taken into account and, probably, equitable support is not being provided to aid their own learning process.

On the other hand, the use of blended learning scenarios allows teachers to use information technologies inside the classroom as a pedagogical and/or didactic strategy supporting students' learning. This work modality probably provides students with opportunities to practice and develop metacognitive abilities in a structured fashion. Thus, high school students would achieve developing autonomy abilities in learning, situation that involves them being more responsible when monitoring and controlling their own learning process as they advance from one module to another.

Finally, the findings contribute empirical evidence on the use of scaffoldings in b-learning environments. This learning strategy, possibly, allows preparing high school students to effectively and autonomously face e-learning courses. Similarly, they would be capable of undertaking the challenge of the requirements that university education implies.

6. Limitations and Suggestions for Future Research

Regarding the use of the optional MSIS scaffolding, it could be suggested that in the first work sessions students mandatorily use a scaffolding and, after this experience, let them decide for themselves whether they use it or not to continue with the development of the learning tasks. This is probably more beneficial for the student insofar as they would be autonomous when deciding on continuing with or without the implemented aid when interacting with computational environments. This would allow analyzing in-depth the advantages and disadvantages of its use during the development of different abilities.

It would be interesting, in future research, to establish the manner how the learning achievement of students that interacted with MSIS is affected and its possible relationship with other psychological variables related to cognitive and learning style, in line with a flexible and equitable education, which respects individual differences, when students interact with computer-based learning scenarios.

It is important to mention that by using a b-learning environment in the research, it is possible that variables may arise that were not controlled in the study; such as the interaction between peers during the development of a learning task, aspect that could be studied furthered in subsequent research. Also, time control for the development of learning tasks, which was not systematically recorded. The study of this variable, regarding time management, would open a research area with regards to self-regulation of learning and the monitoring of set goals. Finally, it would be interesting to study students' motivation toward online learning; variable that could be analyzed in-depth in high school students with the purpose of preparing them to undertake the challenge of continuing with university studies supported by mobile technologies.

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