*Article*

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# Influence of a Metacognitive Scaffolding for Information Search in B-*learning* Courses on Learning Achievement and Its Relationship With Cognitive and Learning Style

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**Abstract**

The research's objective is to evaluate the differential effect that a metacognitive scaffolding for information web searches has on learning achievement of high school students with different cognitive style in the field dependence and independence dimension and on learning style in the dimension proposed by Honey and Alonso known as CHAEA. One hundred and four students from a school in the city of Bogotá, Colombia participated in the study. The research was quasi-experimental and was conducted with three 10th-grade groups, which worked with three scaffolding versions: fixed, optional, and without scaffolding. A multivariate analysis of covariance established that the fixed scaffolding favored learning achievement. Regarding cognitive style in the field dependence and independence dimension, the findings allow to conclude that the field independent students exhibited better

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academic performances in the presence of a fixed scaffolding when compared with the field dependent students. In addition, a positive interaction was identified between cognitive style and the scaffolding that drives learning achievement. However, learning style did not have any effect on academic achievement.

**Keywords**
metacognitive scaffolding, information search, cognitive style, learning style, learning achievement

## Introduction

Recent research has identified an accelerated increase in the use of Internet in educational environments in recent years, which evidences students' preference when they search for information in the development of learning tasks (Arango, Bringué, & Sádala, 2010; NetDay, 2005; Pew Internet & Proyect, 2012; Schalk, 2012). In spite of the generalized use of Internet in the completion of academic assignments, the quality of the assignments submitted by the students is not as expected, and consequently lessons derived from these processes are not the most optimal (Li & Lim, 2008; Wallace, Kupperman, & Krajcik, 2000). This issue is possibly related to learning style (Alonso, Gallego, & Honey, 1997; Lozano & Tijerina, 2013; Martínez, 2012) and to cognitive style (Alomyan, 2004; K. Kim, 2000).

Regarding cognitive style in the *field dependence and independence* (FDI) dimension, studies have established that the subjects referred to as *field dependents,* or those sensitive to the environment, exhibit difficulties browsing the Web efficiently since they quickly become disoriented in these types of environments, which have a hypermedia format, which probably impedes them from obtaining good results when searching for information (Alomyan, 2004; K. Kim, 2000). With regard to the learning styles in the dimension proposed by Alonso et al. (1997), known as CHAEA, it was possible to establish that the subjects with a pragmatic and active style exhibit low learning achievements. They also possess few metacognitive abilities and spend more time looking for information on the Web: They explore diverse sites and divert their attention from the search's main objective (Cuadrado, Fernañdez, Monroy, & Montaño, 2013; Lozano & Tijerina, 2013; Martínez, 2012; Pujol, 2008).

The aforementioned aspects evidence that the subject's stylistic differences can influence information Web searches. In response to this issue, the community of information technologies applied to education design and validate metacognitive scaffoldings that allow students to develop information search abilities, situation that will favor lessons, while still respecting novices' individual differences (Molenaar, Van-Boxtel, & Sleegers, 2010; Quintana, Zhang, & Krajcik, 2005; Zhang & Quintana, 2012; Zohar & Barzilai, 2013).

Regarding the design of scaffoldings in computer-based environments, those that are fixed permanently support the student during learning task development (M. Kim & Hannafin, 2011). On the other hand, optional scaffoldings are available in the computational environment, however, the novice is who decides when to use them (Lakkala, Muukkonen, & Hakkarainen, 2005). With respect to which scaffolding to use, studies are unclear in establishing which of the two favors students' learning achievement more (Chang, Sung, & Chen, 2002; Lakkala et al., 2005).

On the basis of this issue, the following research questions are postulated:

1. Do significant differences exist in high school students' learning achievement when they perform information Web searches supported by fixed, optional, or without a metacognitive scaffolding?
2. Do significant differences exist in the learning achievement of high school students with different cognitive styles in the FDI dimension when they perform information Web searches supported by a metacognitive scaffolding?
3. What effect does a metacognitive scaffolding for information Web searches have on learning achievement in high school students with different learning style in the Honey and Alonso (CHAEA) dimension?

Considering the foregoing, this study posits the design and validation of a metacognitive-type scaffolding for information searches on the Internet to teach chemistry in a course that combines face-to-face and virtual classes, which provides support to subjects with different cognitive and learning styles in order to favor learning achievement.

## Cognitive Styles in the FDI Dimension and Web-based Learning Environments (WBLE)

According to Hederich (2013), the most studied cognitive style is, probably, the one referred to as the FDI proposed by Witkin in 1948. Cognitive style refers to the habitual way in which individuals processes information; it is an individual's stable and conscious characteristic that evidences itself in the development of all their tasks. This dimension establishes differences between subjects related to the cognitive restructuring capacity, information processing, interpersonal, and motivational competencies between two subject polarities: Those referred to as field independent and dependent (Hederich, 2004). These differences among the students influence the learning process, the individual academic achievement, and the manner of accessing knowledge in the WBLE (Belk, Papatheocharous, Germanakos, & Samaras, 2013; Calcaterra, Antonietti, & Underwood, 2005; Chen & Macredie, 2002).

In this line of thought, it was possible to identify that the field independent subjects exhibit greater cognitive restructuring abilities, which are evidenced in their capacity to uncover simple figures within complex figures and process information analytically; situation which allows them to deepen on previously established concepts and make relationships between them. In addition, they possess strategies that facilitate information storage and recovery, show preferences toward individual work, and are intrinsically motivated (Hederich, 2004; López, Hedererich, & Camargo, 2011). On the other hand, there are the field dependent subjects, also referred to as sensitive to the environment, which exhibit fewer capacities in regards to the cognitive restructuring capacity, they process information globally limiting the possibility of conducting inferences and in-depth information analysis, they tend toward group work, and are extrinsically motivated (Hederich, 2004; Tinajero, Lemos, Araújo, Ferraces, & Páramo, 2012).

In contrast, it has been possible to establish that in WBLE field independent subjects: browse freely without following defined paths, are not distracted by graphic aspects, benefit from multimedia resources, and exhibit greater abilities to guide their learning process in these types of environments. On the other hand, the field dependent subjects become disoriented in these environments due to the hypermedia format and require visual aids to browse, they show little interest for multimedia resources, and prefer guided learning (Alomyan, 2004; Jonassen & Grabowski, 1993; Somyuürek, Guüyer, & Atasoy, 2008).

It is possible that the aforementioned aspects are related to the information search's results, in which the independent students exhibit better performances since they possess abilities to identify relevant information, are less influenced by the environment, and are distracted less, hence, their searches are more efficient. On the contrary, dependents have difficulties identifying useful information due to the perceptual field distractions, and they spend more time locating key concepts (Hong, 2002; K. Kim, 2000), characteristics which probably impede them from conducting effective searches in these scenarios.

In summary, the differences between subjects with different cognitive styles when they interact with WBLE are evident. This constitutes a challenge for researchers of information technologies applied to education as the creation of computational scaffoldings or virtual learning environments that allow reducing the differences between both these polarities and improving learning achievement equitably for students are required.

## Learning Styles in the Dimension Proposed by Honey and Alonso and Its Relationship With WBLE

Learning styles refer to students' preferences when processing information and facing a learning task (Alonso, Gallego, & Honey, 1994). The learning styles dimension, proposed by Alonso et al. (1997) known as CHAEA, classifies students into the following four polarities: active, reflective, theoretical, and pragmatic. The ones named *active*, which are characterized for being enthusiasts when faced with something new and tend to act first and think about the consequences later, prefer short term plans, like to work in groups with other subjects, and prefer to be the center of the activities they perform. The *reflective*, on the other hand, tend to adopt an observer's stance that analyzes his or her experiences from different perspectives, they base their learning on data gathering and its subsequent analysis, and in general, they prefer to observe and listen before speaking.

Regarding the *theoretical*, these adapt and integrate their observations into logically based and complex theories. They are characterized for thinking sequentially, they have the tendency of making objective judgments and using logic for problem solving. Lastly, the *pragmatic* students are characterized for being practical, they prefer dynamic discussions, and easily posit ideas and put them into practice. (Alonso et al., 1997).

Research in this field of knowledge has allowed to establish a subject's behavior when they interact with WBLE concluding that the theoretical and reflective are characterized by preferring these types of learning environments, having metacognitive abilities, and exhibiting better academic achievements (Elvira & Pujol, 2012; Escanero, Soria, Ereza, & Sánchez, 2014). Similarly, reflective students perform efficient information searches and spend less time searching (Cázares, 2009; Pujol, 2008). On the contrary, the pragmatic and active distinguish themselves for exhibiting low learning achievements, developing few metacognitive abilities, and spending more time searching for information on the Web (Cuadrado et al., 2013; Lozano & Tijerina, 2013; Martínez, 2012).

In summary, the foregoing studies allow to see the effect of subjects' learning styles when interacting with WBLE and when searching for information efficiently, which is probably related to the active and pragmatic students' low learning achievement in comparison with the theoretical and reflective. This evidences the need to design scaffoldings that favor the development of information search abilities that allows improving learning achievement evenly across all subjects with different learning styles.

## Learning Achievement and Metacognitive Abilities

Metacognitive abilities control and regulate the learning process (Osses, Salamé, & Gálvez, 2007; Schraw, Kent, & Hartley, 2006; Schraw & Moshman, 1995; Veenman, 2011). For example, a student who has developed these abilities recognizes what, how, and when to employ their knowledge, at the same time, they regulate their learning by planning, organizing, monitoring, controlling, and evaluating the development of their educational activities. In this research field, studies have concluded that novices that standout for their learning achievements exhibit metacognitive abilities, which indicate a positive correlation between these two variables (Gul & Shehzad, 2012; Young & Fry, 2008; Zohar & Barzilai, 2013).

According to Tobias and Everson (2009), the development of metacognitive abilities in students allows them to conduct strategic learning, that is to say, they focus on the information that needs to be learned, executing a planning process, strategy selection, learning evaluation, and constant monitoring of the aforementioned processes, which will lead to improving learning achievement. In this line of work, several studies have examined in high school and university students the relationship between learning achievement and metacognitive abilities, concluding that students who exhibit high metacognitive abilities have a better academic performance in different knowledge areas (Gul & Shehzad, 2012; Javanmard, Hoshmandja, & Ahmadzade, 2012; Narang & Saini, 2013; Young & Fry, 2008).

It has also been proven that novices that receive training to develop metacognitive abilities improve their academic performance (Desoete, 2007; Molenaar et al., 2010; Schunk, 2008). For this reason, it is important to continue inquiring into scaffoldings that favor the development of these abilities with the purpose of positively impacting learning, and in this manner, strengthen educational processes in different school levels respecting the subject's individual differences when they interact with computational scenarios.

## Metacognitive Scaffoldings for Information Searches

The concept of *scaffolding* was proposed by Wood, Bruner, and Ross (1976), and it refers to the social support provided to a student during the development of a learning task. In traditional learning environments, the implementation of scaffoldings has had positive effects, and these results are reference points for the information technologies applied to education, which have adapted these approaches in the design of computational scaffoldings, which include in their structure pedagogical elements that support and favor the student's learning process addressing their differential differences (Azevedo, Cromley, & Seibert, 2004; López & Hederich, 2010; Mannheimer, 2010; Molenaar, Roda, Boxtel, & Sleegers, 2012; Sharma & Hannafin, 2004).

In this line of research, there are various types of scaffoldings, among which the explicit metacognitive scaffoldings standout. These are characterized for managing and regulating cognitive processes in an evident manner. In this way, the subject plans his or her learning process, monitors and controls the progress of the proposed goals, and evaluates the obtained results (Molenaar et al., 2010; Quintana et al., 2005). In this research field, several studies have developed explicit metacognitive scaffoldings for information searches (Kuo, Chen, & Hwang, 2014; Li & Lim, 2008; Zhang & Quintana, 2012), which propose that the scaffoldings can be an option to improve information searches efficacy and learning achievement (Molenaar et al., 2010; Quintana et al., 2005).

In this research field, studies have inquired into the effectiveness of fixed and optional scaffoldings. The former provide constant guidance to the student during the development of a learning task (M. Kim & Hannafin, 2011). The latter can be used by students whenever they want (Lakkala et al., 2005). Some studies in the research field assert that fixed scaffoldings improve lessons, while the optional scaffoldings can be ignored by students on some occasions (Chang et al., 2002; Lakkala et al., 2005). On the one hand, some studies have shown that fixed scaffoldings do not favor the learning process to the same extent since they offer the same support to all the students without respecting individual differences and, on the other hand, they do not fade in time making them repetitive independently of the lessons achieved (Renkl & Atkinson, 2003).

These contradictory results suggest that it is necessary to analyze more in-depth the effectiveness of fixed and optional scaffoldings during the development of learning tasks. Considering the presented arguments, the present study posits the design and validation of an explicit metacognitive-type scaffolding with three versions: fixed, optional, and without scaffolding, which implemented in a course that combines face-to-face and virtual classes, can provide support to subjects with different cognitive and learning styles in autonomous information searches, and in this manner, impact the learning achievement derived from this search process.

## Research Methods

### *Design*

The research was conducted with three groups previously organized from the 10th grade of a private school of the city of Bogotá, Colombia and was of a quasi-experimental nature. The research's independent variable was the metacognitive scaffolding for information search (MSIS), which had three values: fixed, optional, and without scaffolding. The study's dependent variable was the learning achievement in the area of chemistry since in this subject, novices exhibit difficulties in virtual task development. The prior learning achievement (ninth grade chemistry grade average) was established as covariables. The associated variables were cognitive style in the FDI dimension and learning style according to CHAEA. The research's data were analyzed through a multivariate analysis of covariance (MANCOVA) and a Bonferroni contrast that was performed through *Statistical Package for the Social Science* 20.0 *software*.

The scaffolding's implementation was done through a general chemistry Moodle course for the 10th grade in a *B-Learning* modality. The course contained eight lessons in which students found educational resources and learning tasks that consisted in searching for information on the Web. The task development was conducted with the help of WBLE as follows: The first group agreed to the optional scaffolding, that is to say, the students had the possibility of using it when they deemed it convenient; the second group developed the learning tasks with the help of the fixed scaffolding; and the third group did not use the scaffolding. At the end of each unit, students submitted an evaluation and a task, whose grades were averaged in order to obtain the learning achievement in each one of the units.

## Participants

The research was conducted at a private school in the locality of Engativá in the city of Bogotá and included the participation of 104 students (61 women and 43 men) of the 10th grade. The ages of the participants ranged between 13 and 17 years old ($M = 15.11$ years, $SD = 0.72$).

## Instruments

*Cognitive style test.* The embedded figures test was the test used to determine the cognitive style in the FDI dimension; the instrument proposed by Sawa (1966) consists of five subtests presented in separate pages. In each page, there is one simple figure and 10 complex figures which must be identified in particular amount of time. The test has been applied in different studies (Ghinea & Chen, 2003; López, Hederich, & Camargo, 2012; López, Ibañez, & Chiguasuque, 2014), which have shown that the internal consistency ranges between 0.85 and 0.95 (Hederich, 2004).

*Learning style test.* This questionnaire consists of 80 items, divided in four sections of 20 questions corresponding to the four learning styles (active, reflective, theoretical, and pragmatic). The test presents a series of statements that students have to answer with the dichotomous score agree (+ symbol) or disagree (− symbol). The absolute score that the student obtains in each section indicates the degree of preference. CHAEA has been validated by several studies reporting high internal confidence intervals, which are found to be above 0.78 (Alonso et al., 1994; Madrigal & Trujillo, 2014).

*Learning achievement.* The learning achievement was obtained from the average of eight single-answer multiple-choice knowledge tests and the assignments in each one of the course's unit lessons. The tests' internal consistency presented a Cronbach's alpha = .871. The assignments were evaluated with the aid of a scoring rubric evaluation, which had the purpose of conducting a standardized appreciation of the students' works (Garayalde, Etxabe, & Iglesias, 2011).

To define the rubric, five criteria were defined to evaluate the learning tasks. The first, analysis, identifies the students' ability to disaggregate a topic into its different components. The second, synthesis, evaluates the novice's capacity of taking elements from diverse sources, integrate them, and state them in their

**Table 1.** Scoring Rubric for the Evaluation of Learning Tasks.

| Scoring rubric for the evaluation of learning tasks | | | |
|---|---|---|---|
| | Level | | |
| Criteria | Advanced | Intermediate | Basic |
| Analysis | Describes in-depth the learning task's concepts and establishes relationships between them. | Basically describes the learning task's concepts and establishes some relationships between them. | Does not submit the description of the learning task's concepts, or what is submitted does not correspond, and in addition does not establish relationships among them. |
| Synthesis | Clearly states the learning task's concepts in their own. | Somewhat inefficiently interprets the concepts indicated in the learning task. | Literary repeats the concepts indicated in the learning task. |
| Writing | Writes with good punctuation and spelling. In addition, their ideas exhibit clear and justified arguments. | Submits text with few spelling and punctuation mistakes. Their arguments are not completely clear and are on occasion not sufficiently justified. | Writes with several spelling and punctuation mistakes. In addition, their ideas do not express clear or justified arguments. |
| Completion | Answers all the learning task's questions. | Answers most the learning task's questions. | Answers a few of the learning task's questions. |
| Use of resources | Uses various images, tables, and examples. | Employs few images, tables, and examples. | Dos not use images, tables, and examples in the learning tasks. |

own words. The third, writing, examines the manner how the subject coherently and consistently expresses the assignment's contents. The fourth, completion, establishes the progress level of the learning task. Lastly, the use of resources refers to the graphs, tables, and examples that the student employs to improve the product of their learning assignment (Table 1).

After defining the evaluation criteria, performance levels were established (advanced, intermediate, basic). Lastly, the descriptors for each one of the levels in the different evaluation criteria were established, which were taken into account when evaluating the tasks sent by the students (Gatica & Uribarren, 2013; Martinez, 2008).

*Metacognitive scaffolding for information search.* The MSIS was developed from the self-regulated learning model based on the information processing theory proposed by Hadwin and Winne (2001). The scaffolding was installed in a course to teach chemistry in the Moodle platform that contained eight units. The course was developed in the *B-Learning* modality during an academic semester, which allowed autonomously combining in-person and other work activities in the platform.

In the in-person encounters, the teacher introduced the unit's topic and indicated the information search assignments. In these spaces, the teacher did not discuss the student's work with the scaffolding. Subsequently, the students independently developed the learning tasks that were available in the platform with the help of the WBLE. With the purpose of improving the students' accessibility to the platform, a domain in the Moodle platform was purchased to conduct the research (http://aulavirtual.adrianahuertas.co). The stages that make up the scaffolding are described later.

***Stage 1. Task perception:*** In this stage, the scaffolding shows the student a description of the planning, execution, and evaluation. These steps guide the information search process with the purpose of answering the learning tasks. Subsequently, the MSIS indicates to the novice the unit's assignment with the purpose of establishing the knowledge they have on the topic and the search strategies that they could implement during the Web search process (Figure 1; Kwon, Hong, & Laffey, 2013; Li & Lim, 2008).

***Stage 2. Search planning:*** In this stage, the novice elaborates a plan to develop the learning task, starting with setting deadlines, selecting keywords, establishing

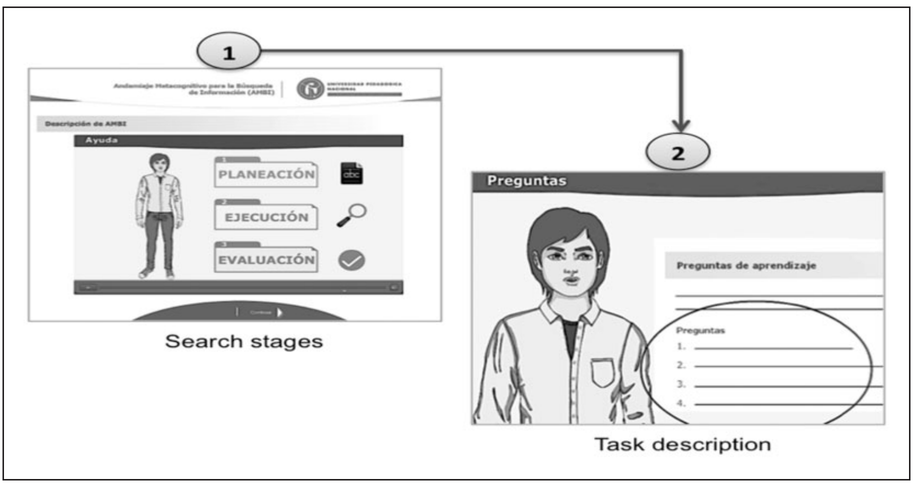


**Figure 1.** Learning task perception.

a learning goal, and the selection of sites for the information search (Yelland & Masters, 2007; Zhang & Quintana, 2012). Monitoring and control is induced through a pop-up window called “Thinking my planning,” which seeks to encourage the student to adjust the aforementioned aspects according to the learning task’s requirements, and in this manner, efficiently answer the information search (Molenaar et al., 2010; Quintana et al., 2005).

The window “Thinking my planning” allows the novice to modify the aspects of the initial planning since the system repeatedly shows them the options that can be modified according to the novice’s expectations. The foregoing enables a dynamic interaction between the student and MSIS (Figure 2).

***Stage 3. Search execution:*** In this stage, the novice searches for the information in the selected sites (search engines, webpages, and databases). In the case of the search engines, the student inputs the key term, and MSIS shows them the pages that contain information on the subject. Subsequently, the scaffolding requests them to select three pages for them to evaluate according to the reliability criteria that the system possesses (relationship with an educational institution, bibliography, content update, easy to browse, legible contents and graphs, and advertising presence; Friedman, 2005; Maglione & Varlotta, 2012; Notess, 2006). If the evaluation of the reliability criteria is satisfactory fulfilled, the system saves the URL of the selected pages, and the student begins the information search; if, on the contrary, said criteria are not fulfilled, MSIS requests them to search other pages (Figure 3).

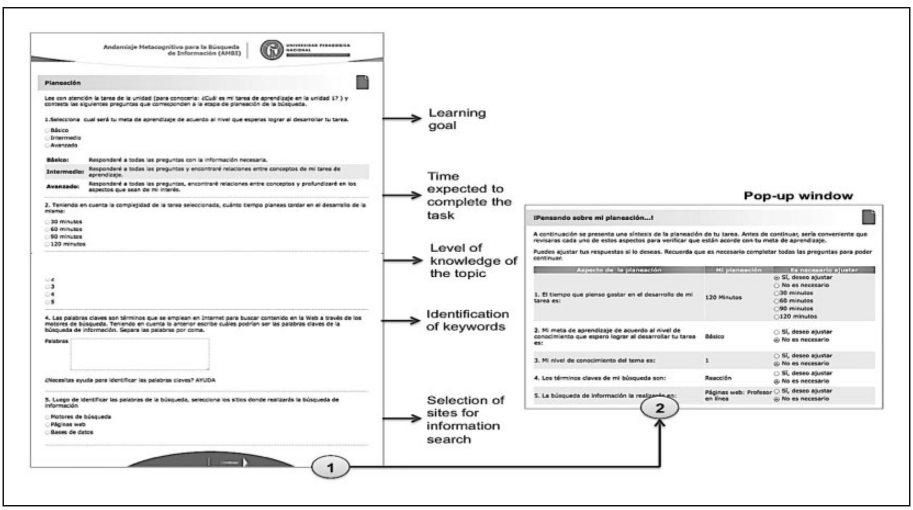


**Figure 2.** Information search planning.

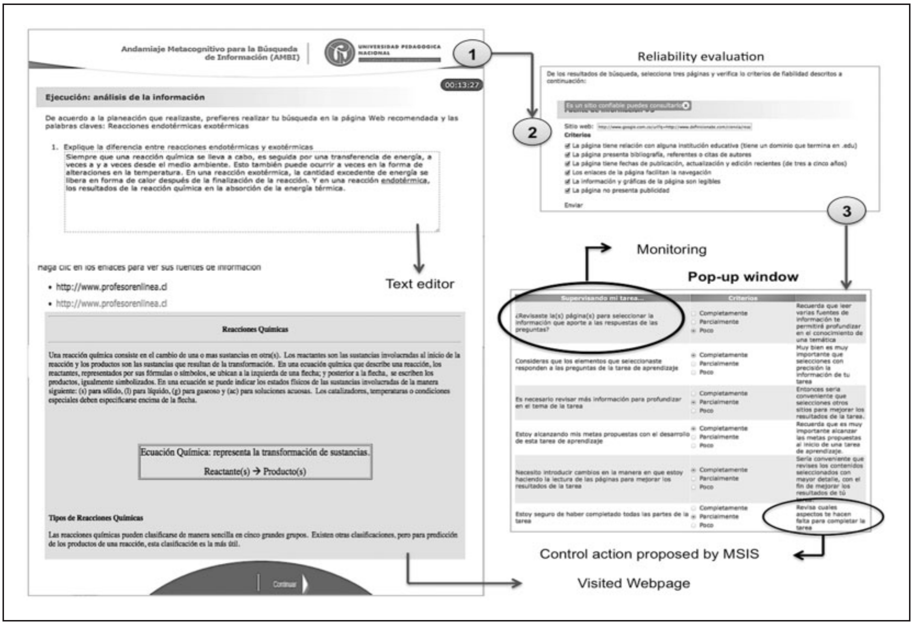


**Figure 3.** Search execution.

The novice searches the reliable pages in order to begin the analysis of information. To this end, they have a text editor that allows them to copy the pages' relevant aspects. Once they have completed reading and analyzing the contents, the pop-up window "Supervising my task . . . " induces the monitoring and control, in which the novice is questioned on the comprehension level, and depth reached regarding the reviewed contents; from this valuation, the system provides feedback and indicates not to proceed until the desired minimum requirements are fulfilled (Nelson & Narens, 1990).

Subsequently, the scaffolding presents the student with the selected information and requests them to reread it and elaborate a summary of the information in their own words that answers the learning task (Mannheimer, 2010; Zhang & Quintana, 2012).

***Stage 4. Search results:*** In this stage, the scaffolding provides the novice with arguments for them to perform their learning task's evaluation from the following aspects: the quality of the answers, depth level, the knowledge reached in the search, and the effectiveness of the sites that were searched (Kwon et al., 2013). Through these judgments, changes are induced in future information searches through the MSIS. Finally, the scaffolding allows the students to download the unit's learning task, which is sent to the teacher through the Moodle platform (Figure 4).

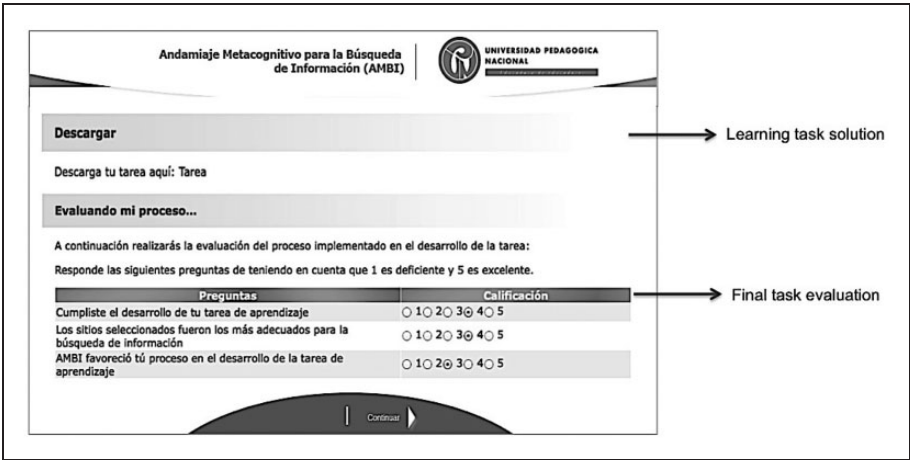


**Figure 4.** Evaluation of results.

MSIS, evidently, presents the characteristics of an explicit scaffolding since it offers support in the search for information that guides the student to manage and regulate the development of their learning task (Hadwin & Winne, 2001; Molenaar et al., 2010; Quintana et al., 2005). It also establishes permanent instructions during the development of the tasks, characteristic aspect of a static scaffolding (M. Kim & Hannafin, 2011).

*Procedure.* In the first place, to conduct the research, the school board was contacted, which accepted the participation of the 10th grade students in the study after explain to them what it consisted of. Subsequently, a proposal was presented to the students and chemistry teachers. Then, the parents were asked for their consent to allow their children to participate in the study, previously clarifying that the results would be confidential and for research purposes. Once the informed consent forms were gathered from the parents, the embedded figures test questionnaire and CHAEA test were applied.

Next, students were presented to the course in Moodle to teach chemistry. Knowledge sessions of the platform were conducted in which users and passwords were provided. In addition, it was verified that none of the students had issues with their access. The research worked with three student courses organized at the beginning of the school year by the educational institution. Hence, the research is quasi-experimental. One of these courses accessed the optional scaffolding, another used the fixed scaffolding, and the remaining one did not use the scaffolding (Table 2).

**Table 2.** Study's Group Size.

| MSIS | Number of students | Cognitive style | | | Learning style | | | |
|---|---|---|---|---|---|---|---|---|
| | | FD | INT | FI | A | R | T | P |
| Fixed scaffolding | 40 | 10 | 12 | 18 | 7 | 4 | 16 | 13 |
| Optional scaffolding | 34 | 13 | 9 | 12 | 6 | 7 | 10 | 11 |
| Without scaffolding | 30 | 12 | 13 | 5 | 12 | 6 | 5 | 7 |
| Total | 104 | 35 | 34 | 35 | 25 | 17 | 31 | 31 |

*Note.* MSIS: metacognitive scaffolding for information search; FD: field dependent; INT: intermediate; FI: field independent; A: active; R: reflective; T: theoretical; P: pragmatic.

**Table 3.** Students' Prior Achievement According to Cognitive and Learning.

| | Cognitive style | | | Learning style | | | |
|---|---|---|---|---|---|---|---|
| | FD | INT | FI | A | R | T | P |
| Prior learning achievement | 7.148 | 6.682 | 7.222 | 7.280 | 6.847 | 9.922 | 7.000 |

*Note.* FD: field dependent; INT: intermediate; FI: field independent; A: active; R: reflective; T: theoretical; P: pragmatic.

## Findings

To determine the prior achievement of the students who participated in the study, the institutional education's board was requested to provide the students' performance average in the subject of chemistry corresponding to the immediately previous year. The academic performance is reported in a scale from 1 to 10. The average is of 7.09, with a standard deviation (*SD*) of 1.319. Table 3 shows the students' performance according to their cognitive and learning style.

To analyze the effect of the independent variable MSIS and the associated variables cognitive style and learning style on the dependent variable learning achievement, a multivariate analysis of covariance was performed (Table 4). The results show that the model explains 73.4 % of the variance in learning achievement.

Regarding the independent variable, the scaffolding (MSIS) shows significant effects on learning achievement ($F(2,73) = 6.153$; $p \leq .003$; $\eta^2 = 0.144$) since the results show that the students who worked with the fixed scaffolding obtained better performance in comparison with the subjects that worked with the optional scaffolding (Figure 5).

An effect of the cognitive style is observed ($F(2,73) = 60.01$; $p < .001$; $\eta^2 = 0.622$) in the sense that the field independent students obtained better

**Table 4.** Results of the MANCOVA.

| Origin | Sum of squares Type III | gl | Mean square | $F$ | $\rho$ | $\eta^2$ |
|---|---|---|---|---|---|---|
| Adjusted model | 340.17[a] | 30 | 11.33 | 10.481 | 0.000 | 0.812 |
| Intersection | 32.86 | 1 | 32.86 | 30.372 | 0.000 | 0.294 |
| Ninth grade grades | 1.27 | 1 | 1.27 | 1.174 | 0.282 | 0.016 |
| MSIS | 13.31 | 2 | 6.65 | 6.153 | 0.003 | 0.144 |
| Cognitive style | 129.86 | 2 | 64.93 | 60.017 | 0.000 | 0.622 |
| Learning style | 1.59 | 3 | .53 | 0.491 | 0.690 | 0.020 |
| MSIS × Cognitive style | 12.00 | 4 | 3.00 | 2.773 | 0.033 | 0.132 |
| MSIS × Learning style | 2.22 | 6 | .37 | 0.342 | 0.912 | 0.027 |
| Cognitive style × Learning style | 2.51 | 6 | .41 | 0.387 | 0.885 | 0.031 |
| MSIS × Cognitive style × Learning style | 9.23 | 6 | 1.54 | 1.423 | 0.217 | 0.105 |
| Deviation | 78.980 | 73 | 1.082 | | | |
| Total | 4553.851 | 104 | | | | |
| Adjusted total | 419.158 | 103 | | | | |

*Note*. MANCOVA: multivariate covariance analysis; : metacognitive scaffolding for information search.
[a]Dependent variable: Learning achievement $R^2 = .812$ (adjusted $R^2 = .734$).

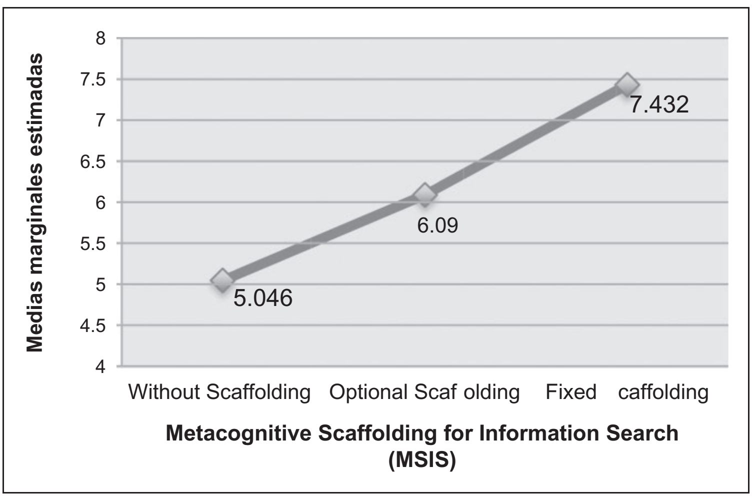


**Figure 5.** Learning achievement in the MSIS modalities. MSIS: metacognitive scaffolding for information search.

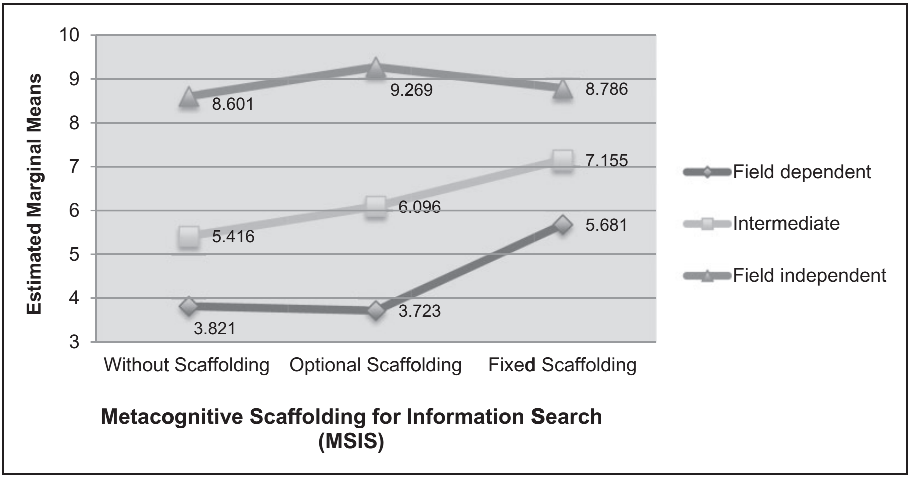


**Figure 6.** Learning achievement according to the cognitive style in the MSIS modalities. MSIS: metacognitive scaffolding for information search.

**Table 5.** Bonferroni Contrast to Compare Learning Achievement and Cognitive Style.

| Dependent variable | (I) Cognitive style | (J) Cognitive style | Mean difference (I–J) | Standard deviation | Significance[b] | Confidence interval at 95% on the difference[d] Lower limit | Upper limit |
|---|---|---|---|---|---|---|---|
| Learning achievement | FD | INT | −1.873[a] | .285 | .000 | −2.573 | −1.174 |
| | | FI | −4.572[a] | .373 | .000 | −5.485 | −3.658 |
| | INT | FD | 1.873[a] | .285 | .000 | 1.174 | 2.573 |
| | | FI | −2.698[a] | .322 | .000 | −3.487 | −1.909 |
| | FI | FD | 4.572[a] | .373 | .000 | 3.658 | 5.485 |
| | | INT | 2.698[a] | .322 | .000 | 1.909 | 3.487 |

*Note.* FD: field dependent; INT: intermediate; FI: field independent. Based on estimated marginal means.
[a]Mean difference is significant at the level.
[b]Adjustment for multiple comparisons: Bonferroni.

achievements in the knowledge tests, followed by the intermediate, and these by the dependents (Figure 6). Similarly, the results show an interaction of the scaffolding with cognitive style ($F(4,73) = 2.773$; $p \leq .033$; $\eta^2 = 0.132$), which means that the independent students improved their learning achievement with the aid

**Table 6.** Bonferroni Contrast to Compare Learning Achievement and Scaffolding Type.

| Dependent variable | (I) MSIS | (J) MSIS | Mean difference (I–J) | Standard deviation | Significance[b] | Confidence interval at 95% on the difference[d] Lower limit | Upper limit |
|---|---|---|---|---|---|---|---|
| Learning achievement | Fixed scaffolding | Optional scaffolding | .86[a] | .31 | .020 | .108 | 1.624 |
| | | Without scaffolding | 1.78[a] | .32 | .000 | .984 | 2.591 |
| | Optional scaffolding | Without scaffolding | .92[a] | .30 | .012 | .165 | 1.678 |
| | | Fixed scaffolding | −.86[a] | .31 | .020 | −1.624 | −.108 |
| | Without scaffolding | Optional scaffolding | −.92[a] | .30 | .012 | −1.678 | −.165 |
| | | Fixed scaffolding | −1.78[a] | .32 | .000 | −2.591 | −.984 |

*Note.* MSIS: metacognitive scaffolding for information search. Based on estimated marginal means.
[a]Significant differences between the groups.
[b]Adjustment for multiple comparisons: Bonferroni.

of the optional scaffolding, while the intermediate and field dependent students were favored by the interaction with the fixed scaffolding.

To explore the effect of the scaffolding on learning achievement and its relationship with cognitive style, the Bonferroni contrast was performed. Table 5 presents the results that indicate significant differences between the field dependent students, intermediates, and field dependents ($p < .001$).

The results in Table 6 show significant differences between the learning achievement of the students who interacted with the fixed MSIS, the optional, and without scaffolding ($p < .05$), that is to say, the students who completed the tasks with the fixed scaffolding obtained better learning achievements.

## Discussion and Conclusions

This research evaluates the differential effect that a metacognitive scaffolding with three versions: fixed, optional, and without scaffolding, has on learning achievement in high school students with different cognitive and learning style. Findings show the existence of a high explanatory capacity of learning achievement by the independent variable (MSIS) and its relationship to cognitive style.

The study's analyses indicate that the fixed metacognitive scaffoldings favor Web information searches, aspect that is evidenced in the learning achievement. The foregoing constitutes an empirical demonstration in this research area and supports the findings of different studies who relate learning achievement, cognitive styles, and scaffoldings. In addition, according to this analysis, it can be asserted that the students who interacted with the fixed scaffolding exhibited better learning achievements in comparison with the students who interacted with the optional scaffolding and those who did not use it. This finding coincides with previous studies that discuss that fixed scaffoldings favor, to a certain extent, learning achievement (Christof, Ingo, & Frank, 2010; Ge, 2005; Jacobson & Archodidou, 2000; Shapliro, 2000).

A possible explanation for the results of the optional scaffolding is that the students do not perceive it as a tool that can guide the development of their learning tasks on the Web and they continue to search for information applying the strategies already known to them, even though these are not the most effective. This is probably due to novices not having direct experience with the use of the scaffolding and, therefore, they are unaware of its benefits and potentiality for task development. These results are analogous to that of other studies that had metacognitive tools as didactic aids in Web environments, which concluded that the students have ignored these during the development of educational activities (Narciss, Proske, & Koerndle, 2007; Proske, Narciss, & Koürndle, 2007).

Similarly, the findings reveal that the implementation of MSIS in the fixed version in courses that combine face-to-face and virtual classes improves the educational achievement of chemistry and probably favor autonomy in learning, without the guidance of the teacher in spaces different to the traditional ones. In this sense, it could be considered that the scaffolding favors the transfer of responsibility to the novice of their own learning process. The foregoing aspects show the effectiveness of the fixed metacognitive scaffolding when it is used autonomously in the development of learning tasks. The fixed scaffolding, then, constitutes a pedagogical or didactic strategy to foster virtual work among students, and it would be an educational strategy to prepare them to access completely e-learning courses, competency that is necessary to develop since high school courses (Huertas, Vesga, Vergara, & Romero, 2015; López, 2015).

On the other hand, regarding the scaffolding's explicit characteristics, it can be established that each one of the MSIS stages favors the information search process fostering: (a) efficiency in planning and (b) the information analysis in the execution and reflection of the task in the evaluation. Aspects that undoubtedly had an impact on the learning achievement in subjects of 10th grade general chemistry, which is consistent with other studies that conclude that the use of explicit metacognitive scaffoldings favors academic performance (Kuo et al., 2014; Li & Lim, 2008; Zhang & Quintana, 2012).

From another point of view, the results support the findings of various studies that prove the effectiveness of metacognitive scaffoldings when novices develop learning tasks in different knowledge areas with the support of WBLE. In this sense, it was established that the presence of MSIS favors the development of tasks that allow the student to plan the information search activity through tools with which they can verify the reliability of the visited sites, the different information sources, among others, in addition to stimulating the reflection on the processes to be followed in the information search. Consequently, this type of scaffoldings could probably help students in task development, autonomously through the Web.

Regarding the cognitive style in the FDI dimension, the results complement the findings of other studies that conclude that the field independent students exhibit better learning achievements in comparison with field dependent students when they interact with WBLE (Calcaterra et al., 2005; K. Kim, 2000; H. Kim, Yun, & Kim, 2004). Additionally, the analysis of the results allows deducing that the field independent students benefited more from the interaction with the scaffolding since they exhibited better academic performances in comparison with the intermediates and field dependents. Similarly, it can be established that the intermediate and field dependent students were benefited in comparison to the students who did not use said scaffolding. This means that the fixed metacognitive scaffoldings positively favor field dependent and intermediate students' learning.

In contrast, the study did not identify any relationship between the metacognitive scaffolding and educational achievement or learning style, which is probably related to the students' preferences when searching for information and facing a task in a virtual environment. These results are coherent with Pujol (2008), who found that learning styles and the frequency of use of metacognitive strategies are not significant in relation to the quality of the learning tasks. In other words, the different learning styles in the CHAEA dimension respond similarly to the information searches.

The results also exhibit coherence with the findings of González, Padilla, and Arias (2010) since the researchers identified that the learning tasks and academic achievement of the subjects when they interact in virtual environments do not present statistically significant differences between learning styles in the CHAEA dimension. However, this type of research must be continued in order to understand and comprehend subjects' conduct according to their learning style when interacting with computational environments.

In contrast, the study of Cázares (2009) established that the students with a reflective learning style exhibit better results in information searches on the Web. These results indicate a lack of research on the subject with which would help in clearly establishing learning achievement and the quality of the tasks in WBLE, taking into account the learning styles in the CHAEA dimension.

Finally, this analysis is expected to contribute to the knowledge of elements that affect students' performance when they search for information on the Web supported by metacognitive scaffoldings. New questions arise on how to drive the information search processes and the impact that this generates on educational achievement, but there are still many solutions from WBLE, which will allow improving the results of the searches in order to optimize lessons.

## Limitations and Forecasts

One of the study's limitation is related to WBLE since the scaffolding does not perform the initial characterization of the students that allows providing them differential support during the information search. In this sense, future research could consider including in the scaffolding elements that adapt to the psychological characteristics and learning needs of the subjects when they search for information on the Web.

Regarding the use of the optional scaffolding, it could be suggested that, in the first search sessions, the students use a fixed scaffolding and later, gradually, be allowed to optionally access the scaffolding in order to get to know the advantages of using a scaffolding that guides and teaches new ways of efficiently searching for information.

Lastly, in posterior studies, it would be interesting to correlate students' learning achievement to the development of metacognitive abilities during information searches in order to establish theoretical references that support the importance of conducting efficient Web searches.

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