# EFFECT OF MOTIVATIONAL SCAFFOLDING ON E-LEARNING ENVIRONMENTS: SELF-EFFICACY, LEARNING ACHIEVEMENT, AND COGNITIVE STYLE

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## ABSTRACT

*The present research studies the effects of motivational scaffolding that favor self-efficacy and improve learning achievement in students with different cognitive styles in the Field Dependence/Independence (FDI) dimension, when they interact in an e-learning environment on mathematics. The research has an experimental design with two groups and a posttest. One group of students interacted with an e-learning environment that contained the motivational scaffolding within its structure and the other group interacted with a computational environment without the scaffolding. The results showed significant differences in learning achievement and academic self-efficacy attributable to the effect of the scaffolding. In addition, it was found that the interaction with the computational environment neutralized cognitive style effects.*

*Keywords: scaffolding, self-efficacy, cognitive style, learning achievement, e-learning environment.*

## INTRODUCTION

E-learning environments are frequently used in higher education as a support to education processes in different domains and levels of knowledge. They offer a set of pedagogical and technological resources that favor equitable learning processes and are able to answer students' learning needs (Akdemir & Koszalka, 2008; Rienties et al., 2012; Wichadee, 2014). These educational scenarios allow students to log on from any place at any time and access information in multiple formats with no physical or temporal barriers; however, students' learning results are less than expected (Allen, Bourhis, Burrell, & Mabry, 2002; Brown & Liedholm, 2002; Guan, Tsai, & Hwang, 2006).

Some authors posit that students' learning achievement, when interacting with Web environments, can be associated with two of their psychological characteristics: academic self-efficacy (Chuang, Lin, & Tsai, 2015; Hodges, 2008; Jan, 2015; Tsai, Chuang, Liang, & Tsai, 2011) and cognitive style (Alomyan, 2004; Chen, 2010; Oh & Lim, 2005). The results of several studies show that students with low levels of self-efficacy have difficulties performing effectively when interacting with Web scenarios, which leads to low academic achievements and to a lack of motivation toward learning. Similarly, self-efficacy produces differential effects in students with respect to the way they participate in and respond to learning situations in Web environments (Cheng & Tsai, 2011; Shen, Cho, Tsai, & Marra, 2013; Torkzadeh, Chang, & Demirhan, 2006).

Regarding cognitive style in the Field Dependence/Independence (FDI) dimension, some studies show that field-dependent subjects present more difficulties browsing environments in a hypermedia format like the Web, as they are easily disoriented. Consequently, they lose control of their own learning process, which prevents them from obtaining good academic performances compared to their field independent classmates, who show better performances when interacting with Web environments (Alomyan, 2004; Handal & Herrington, 2004).

In this sense, students' self-efficacy perception and stylistic characteristics are associated with learning achievement when subjects interact in Web environments. To address students' individual characteristics, researchers in education propose that the design and implementation of motivational scaffolding within the structure of the computational environment should favor learning achievement and improve students' personal beliefs regarding their abilities to learn in Web environments (López & Triana, 2013). However, research results are still in a preliminary state; therefore, it is necessary to continue investigating this to understand and comprehend students' behavior when they interact with a computational environment and to propose alternative solutions that favor obtaining more equitable learning achievements that take students' individual differences into account.

Based on these approaches, the present study intends to answer the following research questions:

1. What influence does the motivational scaffolding have on academic self-efficacy and learning achievement in higher education students that learn mathematical content in an e-learning environment?

2. Do significant differences exist in learning achievement and academic self-efficacy between subjects with different cognitive styles in the FDI dimension when they interact with an e-learning environment that contains the motivational scaffolding?

## LITERATURE REVIEW

### *Self-efficacy and Computational Environments*

The concept of self-efficacy or personal efficacy is developed in Bandura's (1986) Cognitive Social Theory. Self-efficacy is defined as the judgements that individuals make about their own abilities to organize and execute necessary courses of action to achieve different objectives (Bandura, 1997). An important number of studies show that students' self-efficacy, or the beliefs about their abilities, are closely related to motivation toward learning (Hodges, 2008). Bandura (1986, 1997) posits four main sources of information that determine individuals' self-efficacy: 1) successful or domain experiences, 2) vicarious experiences, 3) verbal persuasion and social influence, and 4) physiological states. Of these, successful experiences are the most effective way of creating a strong sense of self-efficacy in students that leads them to commit to their own learning process to achieve proposed learning goals (Girasoli & Hannafin, 2008; Schunk, 1991).

In the educational realm, the application of the theory of self-efficacy has shown that high efficacy perceptions in the execution of academic tasks translate into higher levels of student motivation toward learning and greater academic performances. Students with these characteristics can manage their own learning and are very confident in their internal referents (Schunk, 1991; Zimmerman, Bandura, & Martinez-Pons, 1992). Some researchers state that this variable significantly influences cognitive process activation and increases effort and persistence to achieve proposed goals and overcome difficulties as they arise (Bandura, 1997; Schunk, 1991; Zimmerman et al., 1992).

In an Information and Communication Technology (ICT) context, self-efficacy has been approached by diverse authors since the 1990s. The initial research in this field focused on studying perceptions about individuals' efficacy regarding their abilities when using a computer and its applications (Compeau & Higgins, 1995). Results showed that self-efficacy plays an important role in an individual's decision to use a computer and their disposition to learn with one (Torkzadeh et al., 2006). Subsequent studies focused on self-efficacy associated with the use of the Internet and state that an increase in self-efficacy leads to students to be more recursive in the use of strategies and exhibit more favorable attitudes when learning in web-based environments (Eastin & LaRose, 2000; Tsai & Tsai, 2003).

Researchers study students' self-efficacy when the students perform online education processes (Valencia, López, & Sanabria, 2016). For example, Kitsantas and Chow (2007) analyzed the existing relationships between academic self-efficacy and students performance in three learning modalities: e-learning, b-learning, and face-to-face. The first two are mediated by digital technologies and the latter in the absence of these. Results showed that independent of the modality to which the subjects belong, learning achievement is positively associated with self-efficacy. Similarly, Yukselturk and Bulut (2007) examined the factors that impact student's academic success when they learn online. Results indicated that self-efficacy and task value are positively correlated with learning achievement.

More recently, Kim, Glassman, Bartholomew, and Hur (2013) studied the effect of using a Web environment in the development of higher education students in a b-learning modality. Students were assigned to two experimental conditions: the first group to an educational strategy distributed and focused on developing greater autonomy and the second group to a traditional strategy. Results showed significant differences in the levels of self-efficacy that favor the first group. However, the results did not report differences in students' learning achievement.

In sum, the research results on Web-based environments highlight the importance of studying novices' self-efficacy when interacting in Web-based environments because this variable is associated with successful performance, effort, and persistence in the development of learning activities (Jan, 2015; Kim et al., 2013; Kuo, Walker, Schroder, & Belland, 2014; van der Meij, van der Meij, & Harmsen, 2015). Hence, it is important to continue researching whether the use of motivational scaffolding favors students' self-efficacy when learning in Web environments.

*Cognitive Style in the FDI Dimension and Computational Environments*

According to DeTure (2004), the FDI dimension is one of the most studied cognitive style dimensions. Proposed and developed by Herman Witkin and his colleagues, it has a broad theoretical development when applied to the educational context , (Witkin, Moore, Goodenough, & Cox, 1977). The FDI dimension describes individuals along a continuum, where subjects that are located at each end of the continuum are denominated field independents or dependents. Similarly, individuals that are located in the middle of the continuum are denominated intermediates (Liu & Reed, 1994).

Field-independent subjects are characterized by their confidence in internal referents and their intrinsic motivation. They develop an analytical approach toward information that allows them to break it down into its parts and restructure it as a function of their needs. They are highly skilled in organizing, classifying, and storing information, as well as resorting to different clues to recover it (López, Hederich, & Camargo, 2011; Tinajero, Castelo, Guisande, & Páramo, 2011). Field-dependent individuals are characterized by being less analytical and less attentive to detail; they process information globally. They are more sensitive to external signals and tend to take information just as it is presented to them (López et al., 2011). The practical implications of cognitive style in the FDI dimension, in computational environments, indicate that field independent individuals tend to surpass field dependent individuals in different tasks such as browsing strategies, content organization and selection, the use of available resources, and degree of control (Alomyan, 2004; DeTure, 2004; Handal & Herrington, 2004).

In an ICT context, a number of studies inquire into the relationships between cognitive style and learning achievement in computational environments (Angeli, Valanides, & Kirschner, 2009; Huertas, López, & Sanabria, 2017; Liu & Reed, 1994). For example, Angeli et al. (2009) studied the effect of two instruction materials on problem solving performance with a computer modeled tool. For the study, two groups were assembled. The first received the instruction through a diagram and a separate descriptive text, and the second group received the same instruction in an integrated manner. The results showed that field independent students achieved better performances with the integrated instruction material. No differences were reported between field dependent and intermediate students.

López et al. (2011) studied the influence of cognitive style in the FDI dimension on learning achievement in primary students who learned mathematical content in hypermedia environments, whose structure contained scaffolding to favor self-efficacy. Results did not show significant differences in terms of individual learning achievement between field independent and dependent students because of the effect of the computational scaffolding. On the other hand, and in line with the literature, a relationship exists between cognitive style in the FDI dimension and students' self-efficacy. It is possible to assert that field independent subjects have higher efficacy perceptions than field dependent subjects in learning situations in computational environments. This concurs with the study of López et al. (2011), who explored the relationships between cognitive style and self-regulated learning in diverse learning contexts, including computational scenarios.

In this direction, authors assert that field independent students' own stylistic characteristics are positively related to certain motivational variables, including orientation toward intrinsic goals and self-efficacy (López et al., 2011). Similarly, López and Triana (2013), in a research study conducted with basic primary students who learned mathematical content in hypermedia environments, discussed that field independent novices possessed higher levels of self-efficacy than field intermediate and dependent students. DeTure (2004) explored academic achievement predictors in an online distance education context and found that field independent students tend to have higher levels of self-efficacy than field dependent students. However, there were no differences in terms of performance between the two. Results also indicated that cognitive style and self-efficacy were not predictors of students' academic achievement in online courses.

In accordance with the foregoing statements, it is possible to assert that cognitive style in the FDI dimension has been well thought-out as a factor associated with students' learning and performance in different educational contexts; therefore, this variable must be considered in the design of computational scenarios. In the present research, incorporating motivational scaffolding within the structure of an e-learning environment with the purpose of favoring self-efficacy development could be especially useful in minimizing the effects of student's cognitive style and favoring a more equitable learning achievement.

*Computational Scaffolding*

The concept of scaffolding arises from Vygotsky's (1978) Zone of Proximal Development. It refers to the support or aid that a child or novice receives from a knowledgeable adult or colleague to achieve a goal that they are incapable of achieving without assistance. Scaffoldings are designed to support novices with the necessary elements for the development of a learning task beyond their abilities (Wood, Bruner, & Ross, 1976). In the ICT realm, educational scaffolding provides the support or orientation, through an agent or tool, that allows students to actively participate in the execution of a task that would be too complex without this type of support (Duffy & Azevedo, 2015). In this sense, a computer-based scaffolding is a software program that uses strategies such as messages, feedback, expert examples, pop-up windows, and data manipulation tools, among others, to favor students' conceptual comprehension, metacognition, use of strategies, and use of procedures (Belland, Kim, & Hannafin, 2013).

In this field of research, scaffoldings are designed to promote self-regulated learning in different knowledge domains focused on the development of cognitive process regulation (Azevedo, Cromley, Winters, Moos, & Greene, 2005; Devolder, van Braak, & Tondeur, 2012; López et al., 2011). Similarly, this system has also been designed to favor metacognitive processes (Huertas et al., 2017; Molenaar, van Boxtel, & Sleegers, 2010; Quintana et al., 2004; Zhang & Quintana, 2012) and, more recently, motivation (Alias, 2012; Butler & Lumpe, 2008; Chen, 2014; D'Mello, Lehman, & Graesser, 2011; Rienties et al., 2012; van der Meij et al., 2015).

The present research designed the motivational scaffolding to favor students' personal efficacy and respect individual differences in considering cognitive style. Thus, field dependent students are more likely to improve their learning achievement and believe more in their abilities when individually learning mathematical content in Web environments.

## METHOD

*Design*

The research is experimental with a 2 x 3 factorial design. The main factors were: 1) presence or absence of the motivational scaffolding in the e-learning environment and 2) cognitive style, with three values: field dependents, intermediates, and independents. The dependent variables were academic self-efficacy and learning achievement.

*Participants.* Sixty-five (65) students (10 women and 55 men) enrolled in the Bachelor's in Technological Design from the Universidad Pedagógica Nacional in Bogotá, Colombia participated in the research. Their ages varied between 16 and 31 years (M = 20.51 years, SD = 3.20). All participants were first-semester students.

*Instruments.* The participants used the e-learning environment "Introductory Course to Mathematics," which was specifically designed for the development of the present research. The course consists of six learning modules in basic mathematics. Each unit contained text and graphic information, videos, learning activities,

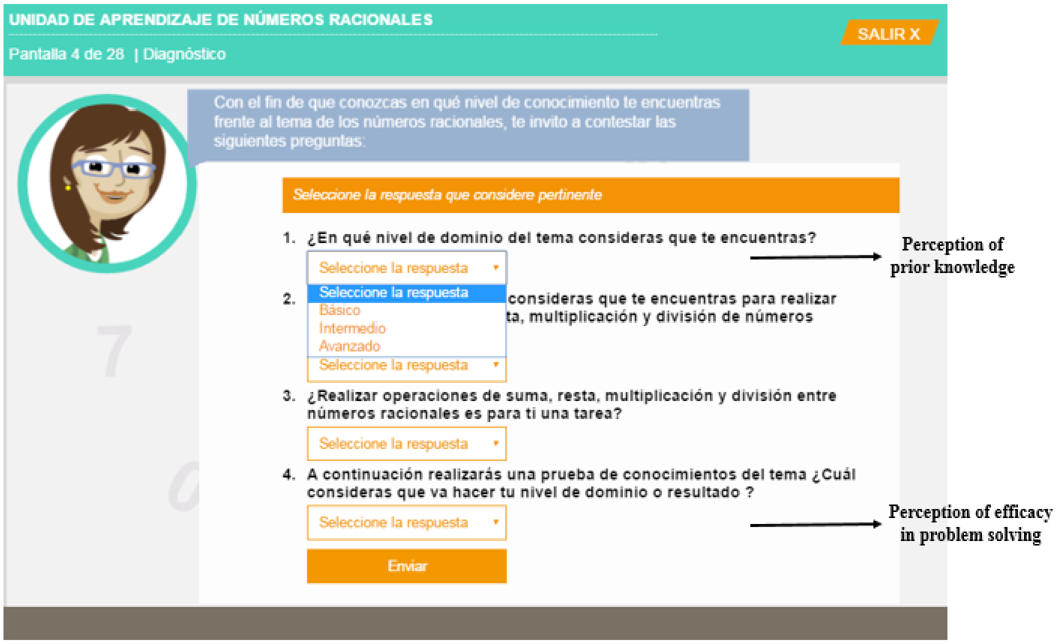


Figure 1. Prior Knowledge Test and Reflection

evaluation tests, and links to Web pages, among other resources. The learning modules can be browsed through a hypermedia structure using a menu.

The design of the scaffolding was based on the theory of self-efficacy developed by Bandura (1986, 1997) and on the postulates for the design of motivational scaffolding proposed by Belland et al. (2013) and Keller (2010). The stages that make up the scaffolding are described below.

*Stage 1. Assessment*. This stage is composed of two elements: 1) Reflection, which is presented through questions that inquire into student's perception of their prior knowledge and of their personal efficacy in basic math problem solving (see figure 1), and 2) Initial test of knowledge, which is composed of three exercises that in turn contain immediate feedback. The purpose of applying this test is that the students compare their actual state of knowledge to their perception of their prior knowledge on the subject matter. This comparison will allow the novice to be more realistic with respect to their abilities and set learning goals in line with their knowledge and abilities.

*Stage 2. Goal formulation and planning.* This phase is composed of three sub-phases:

*1) Learning-goal selection phase.* The scaffolding offers the student the possibility of selecting their own learning goal considering the following scale: a) Basic level, which corresponds to decontextualized operational problem solving; b) Intermediate level, which considers contextualized problem solving with one variable; and c) Advanced level, which presents the student with contextualized problem solving with two or more variables. This goal selection aims to generate student's commitment to themselves and avoid very demanding, or easy, learning situations when setting their learning challenges.

*2) Self-efficacy judgement formulation phase.* This phase shows the students a scale from which they select an option regarding their perception of achieving the previously established learning goal. The options are: Completely certain of achieving it. Certain of achieving it. Mildly certain of achieving it. Insecure of achieving it. Very insecure of achieving it. The purpose of these options is to get the student to reflect on their abilities to reach the learning goal and to be realistic during goal selection.

*3) Planning phase.* During the deployment phase, the students can select the amount of time they will employ in studying each lesson and choose the option that best suits their learning pace (2 hours, 3 hours, 4 hours, 5 hours, or more hours—how many?). In addition, they can select the available resources in the e-learning environment and/or external resources that they deem important to

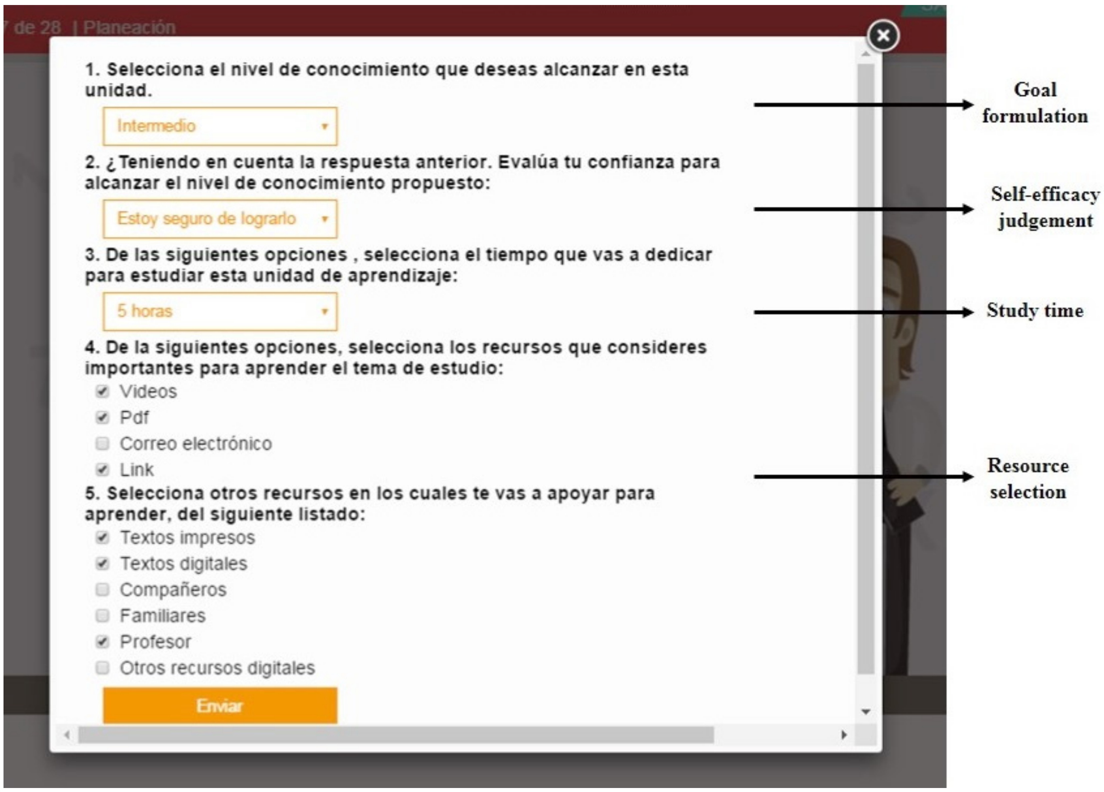


Figure 2. Goal Formulation and Activity Planning

support their learning process (see figure 2). Learning-goal selection, self-efficacy judgment, and planning are visualized by the student, who can modify them at any time during the learning process.

*Stage 3. Learning achievement execution and monitoring.* During this phase, the students browse the e-learning environment and perform their own monitoring process with the purpose of making the necessary adjustments to the planning to achieve the previously proposed learning goal. To that effect, the scaffolding promotes success experiences as the main activator of self-efficacy (Bandura, 1997; Schunk, 1991). To that end, it has a resource called "Supervise your knowledge," which is a self-evaluation module that involves completing exercises equivalent to those of the final evaluation. Similarly, the scaffolding, through screen messages, induces students to continuously self-evaluate and compare the results obtained to their proposed goal.

If the student does not achieve the goal, the scaffolding stimulates them with motivational messages to get them to try harder and persist in achieving it by allowing them to review the content, revise and modify their planning, and do more exercises, thus generating confidence in their knowledge and allowing them to succeed in obtaining the previously established learning goals while taking their individual differences into account. These messages seek to activate the novice's self-efficacy by attributing the success to their ability, effort, and persistence ("Very good! You have proven to have many abilities. Try to obtain better results"; "Excellent! Your results surpassed expectations. Keep it up."). Similarly, if the results of the self-evaluations are less than expected, this type of message stimulates the student to proceed with the proposed goal ("Try to obtain better results, you will surely succeed!"; "Concentrate, you can overcome all the challenges that arise!") (Belland et al., 2013; López & Triana, 2013) (see figure 3).

*Stage 4. Self-evaluation and final reflection.* In this stage, the scaffolding proposes to the students that they complete a final self-evaluation of the learning process. Once a learning module has been evaluated, the novices reflect on the level of

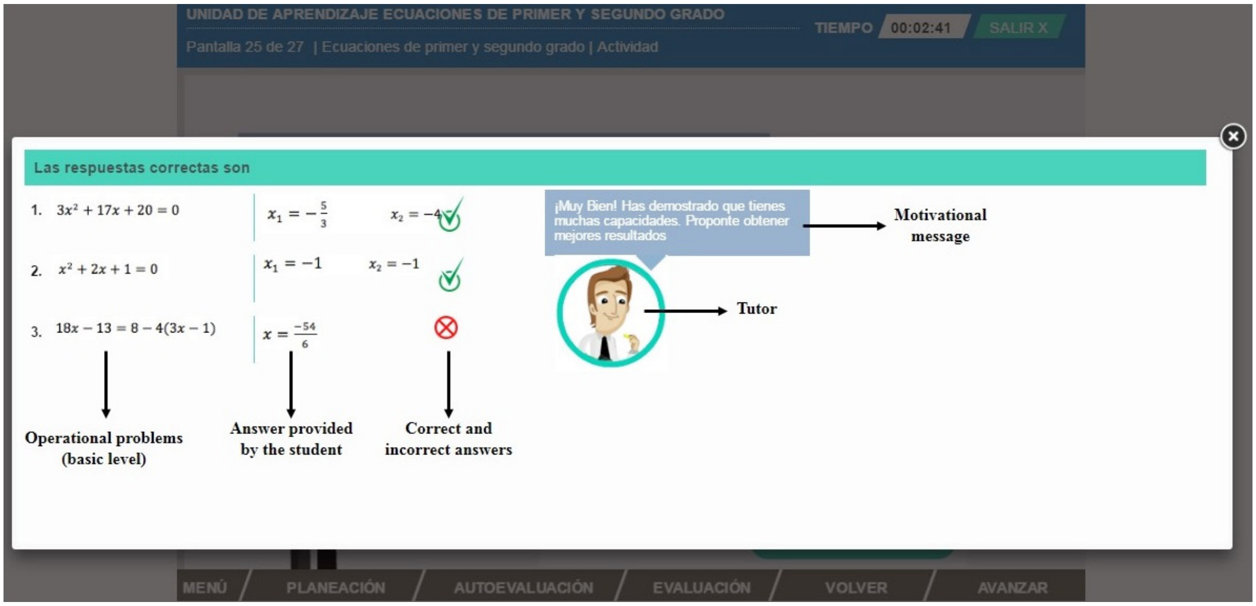


Figure 3. Stimuli Messages for a Basic-Level Self-Evaluation

achievement reached, their efficacy perception, and activity planning. They formulate questions like:

Was the chosen goal the most adequate?

What is your perception of the level of command of the subject?

Was the amount of study time adequate for the results obtained?

Were the resources used adequate?

These types of questions are asked so the students make the corresponding adjustments in the next study modules.

*Cognitive style test.* The Embedded Figures Test (EFT) was used to determine cognitive style in the FDI dimension in the format proposed by Sawa (1966). The test is comprised of five subtests and consists of identifying a simple figure within ten complex figures sequentially organized that must be solved in a pre-established amount of time. With a maximum score of 50 points, the minimum value was 12 and the maximum value 42 (M = 27.46, SD = 7.274). This test has been applied to different research conducted with Colombian students, which have shown an internal consistency that varies between 0.85 and 0.9 (López et al., 2011). Through tertiles, three groups of students were identified, namely: a) 21 field-dependent students (first tertile), b) 21 intermediate subjects (second tertile) and, c) 23 field-independent novices (third tertile).

*Academic self-efficacy subscale of the Motivated for Strategies Learning Questionnaire (MSLQ) instrument.* Students answered the academic self-efficacy subscale of the MSLQ (Pintrich, Smith, Garcia, & McKeachie, 1991). This test has been applied to different research conducted with Colombian students and the results show high reliability indexes (López et al., 2011; López & Valencia, 2012). This self-reporting questionnaire presents eight questions on self-efficacy for learning and performance. The test is answered in accordance to a seven-point Likert scale (1 = No, never;…;7 = Yes, always). The subscale presented a reliability of 0.915.

*Learning achievement.* Learning achievement was obtained from the average of six evaluations taken by students individually (one for each study module contained in the e-learning environment). All the evaluations contained five multiple choice problems. The evaluations were presented in the e-learning environment and the corresponding results were recorded in a database included in the computational environment. The evaluation exhibited a reliability of 0.758.

*Procedure*

To develop the research, the directors of the Bachelor's in Technological Design from the Universidad Pedagógica Nacional were contacted. Next, the proposal was presented to the students

Table 1. Academic Self-efficacy Results: Mean Scores and Standard Deviations

| Group | Cognitive Style | No | Mean | Standard Deviation |
|---|---|---|---|---|
| With Scaffolding | Field dependent | 9 | 5.72 | 0.53 |
| | Field intermediate | 11 | 5.81 | 0.56 |
| | Field independent | 11 | 6.02 | 0.41 |
| | Total | 31 | 5.86 | 0.50 |
| Without Scaffolding | Field dependent | 12 | 4.44 | 0.64 |
| | Field intermediate | 10 | 4.41 | 0.44 |
| | Field independent | 12 | 4.25 | 0.68 |
| | Total | 34 | 4.36 | 0.59 |

and they were asked to complete an informed consent to participate in the research, with the prior clarification that the results would be confidential and for research purposes only. Then, proceeded the group application of the embedded figures test (EFT) was and each of the participants were randomly assigned to one of the experimental conditions.

Afterwards, all the students were given a face-to-face orientation on the e-learning environment and, at the same time, they were given user logins and passwords to access the platform. The study had a two-month duration. It is noteworthy to mention that the students of the control group (without scaffolding) worked under the same conditions as the students of the experimental group (with scaffolding). In other words, the course's objectives, content, multimedia resources, the evaluation, and the study times were the same. They differ only in the presence or absence of the computational scaffolding. One week after the end of the experimental stage, students were given the academic self-efficacy subscale of the MSLQ instrument. The instrument was managed through a form developed in Google Drive.

## RESULTS

For data processing, a Multivariate Analysis of Variance (MANOVA) was conducted. The study's dependent variables were academic self-efficacy and learning achievement. Two main factors were considered: a) the e-learning environment, which has two values: with motivational scaffolding and without scaffolding, and, b) cognitive style with three values: field-dependent, intermediate, and field-independent students. Table 1 and 2 present the averages obtained by the students in self-efficacy and learning achievement.

First, compliance with the assumptions of normality and homogeneity of the covariance matrixes for the dependent variables was verified. For self-efficacy, the Shapiro-Wilk's normality test was used for both the experimental group ($W = 0.956$, $p = 0.232$) and the control group ($W = 0.987$, $p = 0.943$),. Similarly, the normality assumption for learning achievement was verified for both the experimental group ($W = 0.957$, $p = 0.249$) and the control group ($W = 0.942$, $p = 0.071$). Box's M homogeneity test ($F$ (15, 16569.634) = 0.610, $p = 0.869$) was also verified. Once the assumptions were verified and met, the MANOVA was conducted.

From the MANOVA, it can be demonstrated that a significant interaction does not exist between the e-learning environment's main factors X cognitive style with learning achievement ($F$ (2, 59) = 0.424, $p = 0.657$, $\eta 2 = .014$) nor with self-efficacy

Table 2. Learning Achievement Results: Mean Scores and Standard Deviations

| Group | Cognitive Style | No | Mean | Standard Deviation |
|---|---|---|---|---|
| With Scaffolding | Field dependent | 9 | 3.60 | 0.92 |
| | Field intermediate | 11 | 3.87 | 0.91 |
| | Field independent | 11 | 4.03 | 0.65 |
| | Total | 31 | 3.85 | 0.82 |
| Without Scaffolding | Field dependent | 12 | 2.75 | 1.23 |
| | Field intermediate | 10 | 3.31 | 1.01 |
| | Field independent | 12 | 3.71 | 0.82 |
| | Total | 34 | 3.25 | 1.09 |

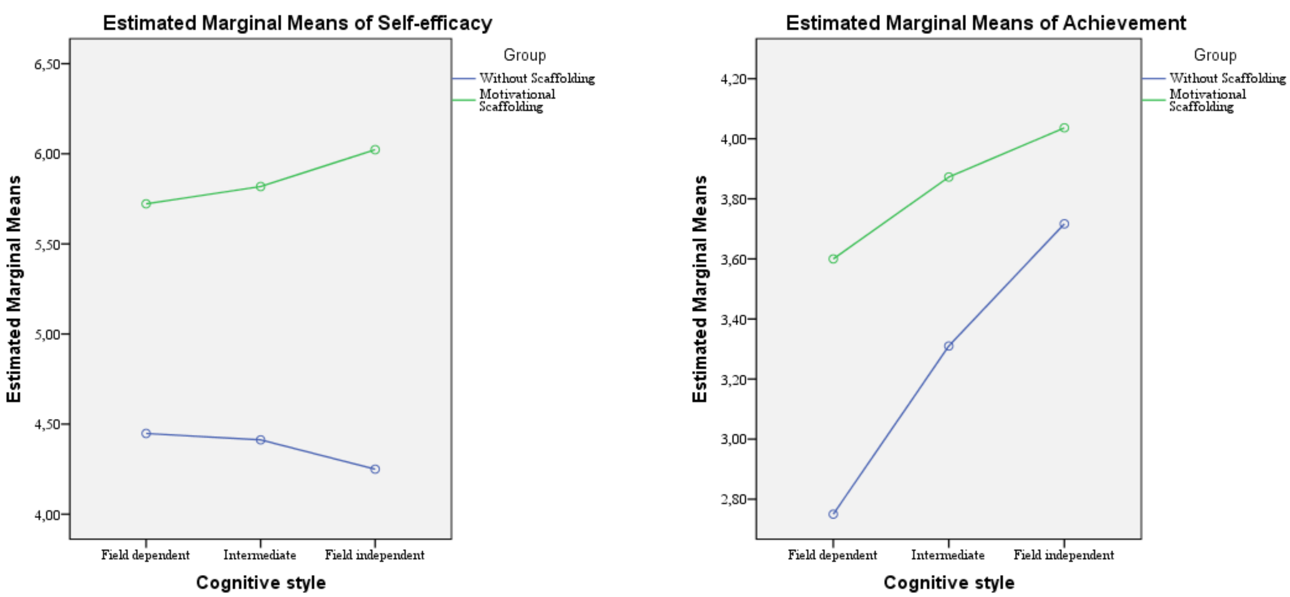


Figure 4. Cognitive Style Effect on Academic Self-Efficacy and Learning Achievement

(F (2, 59) = 1.159, p = 0.321, η2 = .038). Similarly, it is possible to establish that a significant main effect of the e-learning environment exists (F (1, 59) = 111.773, p < = 0.01, η2 = .65) on self-efficacy in favor of the students that interacted with the version of the e-learning environment that included the motivational scaffolding. Students that worked with the scaffolding reported better levels of academic self-efficacy (M = 5.86, SD = 0.50) compared to the students that did not use it (M = 4.36, SD = 0.59) (Table 1) (Figure 4).

Similarly, a significant main effect of the e-learning environment exists (F (1, 59) = 5.954, p = 0.18, η2 = .09) on performance. Students that worked with the scaffolding obtained better learning achievement (M = 3.85, SD = 0,82) compared to the students that did not use it (M = 3.25, SD = 1.09) (Table 2) (Figure 4).

Finally, cognitive style does not have a significant main effect on academic self-efficacy (F (2, 59) = 0.045, p = 0.956, η2 = .002). A significant effect on learning achievement was not reported either (F (2, 59) = 2.981, p = 0.058, η2 = .09). It is noteworthy to mention that the p-value obtained is close to the conventionally accepted value (0.05), a situation that induces a reasonable doubt.

To determine, in greater detail, the influence of cognitive style and the motivational scaffolding on learning achievement, a complementary analysis was conducted to establish if significant differences exist, or not, between learning achievements obtained by students with different cognitive style in the FDI dimension by separately considering the groups that participated in the study. To this end an Analysis of Variance (ANOVA) was performed.

The results indicate that in the control group, different cognitive styles have a significant effect on learning achievement (F (2, 31) = 3.818, p = 0.03, η2 = .19), favoring field-independent students. The multiple comparisons indicate that significant differences exist between field-independent and field-dependent subjects (t (31) = 2.559, p = 0.016) and between field-dependent and intermediate subjects (t (31) = 2.204, p = 0.035). No differences exist between field independent and intermediate novices (t (31) = 0.410, p = 0.684). On the other hand, students that interacted with the version of the e-learning environment that included the motivational scaffolding did not exhibit a significant statistical effect with respect to learning achievement (F (2, 28) = 1.913, p = 0.167, η2 = .12). Consequently, novices' performances, with different cognitive style in the FDI dimension, are equivalent.

## DISCUSSION AND CONCLUSIONS

This study's results show the effectiveness of using motivational scaffolding to favor both learning achievement and academic self-efficacy when students interact in Web environments. Similarly, it was possible to establish that the scaffolding implemented in the computational environment equally favors higher education students' performances when considering their individual differences according to their cognitive style in the FDI dimension. Regarding the first research question, the study was consistent in showing that the use of motivational scaffolding within the structure of an e-learning environment positively influences students' self-efficacy. The fact that students set basic-level learning goals and, as they reach them, they set more demanding goals, makes it possible for them to gain confidence in their abilities to obtain the learning achievement they set for themselves. Thus, their self-efficacy perception is positively affected and their beliefs on learning through the Web improve significantly.

Similarly, the self-evaluation module included within the scaffolding allows the student to learn at their own pace. Thus, each self-evaluation constitutes a small success that leads student' perception of their abilities to learn mathematical content to be positively reinforced. The results show that students persisted and endeavored to obtain the learning goals they pre-established for themselves. Likewise, the motivational message provided by the scaffolding allows the students to motivate themselves to succeed in achieving the goals and hinders the novices from losing motivation in their attempt to achieve the desired performance. These findings constitute empirical evidence in this field of research and support the results of some studies that address the use of motivational scaffolding to favor self-efficacy and learning achievement in computational environments (López & Triana, 2013; López & Valencia, 2012).

The study's findings coincide with the results of the studies by Kim et al. (2013), Kitsantas and Chow (2007), and Yukselturk and Bulut (2007) on the development of self-efficacy and the improvement of academic achievement in Web environments. Similarly, they support the expectations of some authors and the findings of previous studies with respect to the importance of favoring the motivation of students that engage in learning processes in online environments (Alias, 2012; Butler & Lumpe, 2008; Duffy & Azevedo, 2015; Rienties et al., 2012; Tuckman, 2007; van der Meij et al., 2015). With the use of motivational scaffolding, students' attitude toward learning through online courses improves and their results in terms of performance are positively affected.

Regarding the second research question, the results show that no differences exist in learning achievement and self-efficacy between higher education students with different cognitive style in the FDI dimension. In other words, field-independent, intermediate, and field-dependent students achieve equivalent learning and self-efficacy perceptions when learning mathematical content through an e-learning environment that incorporates a motivational scaffolding. Online learning environments should include within their structure tools that favor motivation toward learning and allow the student to set their learning goals, plan their own study process, self-evaluate what they have learned, and reflect on the completed learning process. To this extent, each student learns at their own pace and improves their personal efficacy perception of learning math. Thus, the motivational scaffolding seems to be a good pedagogical strategy to favor learning achievement in those students with difficulties in mathematics, specifically, field-dependent students, who present low learning results and less favorable attitudes in learning math and science in comparison to field-independent students (Hederich & Camargo, 2015; Van Blerkom, 1988).

The study's results are interesting insofar as they suggest that intermediate and field-dependent students achieved learning equivalent to that of field-independent students, which implies that this type of novices should try harder and persist in achieving self-imposed goals. Although these results are inconclusive, they suggest that in this line of research the design of motivational scaffolding can favor field-dependent student learning and justifies looking deeper into their design and implementation in online scenarios.

It is worth mentioning that the results of the present research contradicted the findings of DeTure (2004), who found that self-efficacy and cognitive style are not predictors of learning achievement in higher education students. In DeTure's study, participants freely enrolled in an online general-education course and their ages varied between 18 and 58 years.His study was of a correlational type in contrast to the research described herein, which was of an experimental type and included the design of the motivational scaffolding. Therefore, it would be necessary to continue with this experimental type of research in this line of study.

In conclusion, the incorporation of computational scaffolding in Web environments to favor students' motivational dimension is recommended to equitably and flexibly improve their learning experience while considering their individual differences. The use of scaffolding enables the student to regulate and control their own learning process in an environment where they do not possess any community support from teachers or classmates.

This research helps understand the factors that can influence higher education students' performance and motivation when they learn content in an e-learning environment. Hence, new questions arise relating to the implementation of pedagogical and technological solutions that maximize self-efficacy with the purpose of favoring student learning in Web environments.

## LIMITATIONS AND FORECASTS

Some limitations that were present when approaching the research were: a) the sample size, insofar as a greater number of participants would have allowed generalizing the study's findings; b) the use of synchronous and asynchronous communication tools would have possibly helped students to work in a team, a situation that may favor the development of collective efficacy and, in turn, personal efficacy; and c) the instrument that was used to measure academic self-efficacy is a self-reporting questionnaire, where students tend to provide socially accepted answers, and has a highly subjective component. Therefore, it would be convenient to use other indicators that show students' self-efficacy more objectively.

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