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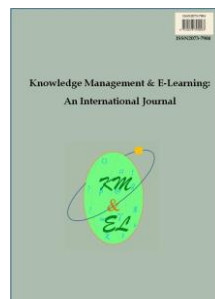
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Knowledge Management & E-Learning: An International Journal (KM&EL)
ISSN 2073-7904

Recommended citation:

López-Vargas, O., Garavito-Martínez, L., & Valencia-Vallejo, N. (2025). Effect of motivational scaffolding on self-efficacy, procrastination, and learning achievement in students of different cognitive styles. *Knowledge Management & E-Learning*, 17(1), 49–70. <https://doi.org/10.34105/j.kmel.2025.17.002>

Effect of motivational scaffolding on self-efficacy, procrastination, and learning achievement in students of different cognitive styles

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Abstract: This research analyzes the effects of motivational scaffolding on procrastination, learning achievement, and academic and online self-efficacy in students with differing cognitive styles in the dimension of field dependence-independence (FDI), that are learning mathematical content in m-learning environments. This study involved 87 students from two seventh-grade classes from a public school in the municipality of Cundinamarca, Colombia. The research followed a quasi-experimental design. A group of students worked through an m-learning environment, which included within its structure a motivational scaffolding. Another group worked through an m-learning environment that did not include a scaffolding. All students were given the EFT masked figures test to classify them into field-dependent, intermediate and independent. A MANCOVA factor analysis was performed. The results indicate that scaffolding favored academic and online self-efficacy. It is possible to assert that field-dependent subjects are inclined to procrastinate and exhibit low levels of academic self-efficacy versus intermediate and field-independent peers. The data show that students with different cognitive styles achieved equivalent learning because of scaffolding in the m-learning environment. It was also concluded that both academic and online self-efficacy of field-dependent students may be favored by the interaction of scaffolding included in the m-learning environment and their cognitive style.

Keywords: Scaffolding; Procrastination; Self-efficacy; Cognitive style; Mobile learning

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1. Introduction

M-learning environments (mobile learning) may be used by the teacher as an aid for the teaching/learning process. In educational practice, these scenarios are a source of opportunities because they facilitate access to information, are multifunctional, are portable by the user, are customized, are highly flexible in the use of platforms and, most importantly, their widespread use, among other characteristics. In this sense, mobile technologies are capable of favoring and enriching student learning at different levels of schooling.

It is noteworthy to mention that because of the health emergency (coronavirus, COVID-19), the use of mobile telephones and/or tablets increased in school environments and therefore has gained relevance and a certain degree of acceptance by the academic community. In this sense, the use of m-learning environments draws the attention of both educators and researchers in the field of education and information technologies (Asghar et al., 2021; Chang et al., 2016; Okai-Ugbaje et al., 2022; Shuja et al., 2019).

Some researchers assert that the use of m-learning scenarios favor academic performance and the development of learning self-regulation skills (Broadbent et al., 2020; Zheng et al., 2018). Also, these scenarios are said to generate positive effects on motivation towards learning (Chang et al., 2016; Jeno et al., 2019; Li et al., 2018). It is also stated that mobile technologies have the ability to favorably aid social interactions in educational contexts (Bere, 2019; Ray & Saeed, 2015). Despite the potential that m-learning scenarios represent in an educational setting, their acceptance and application have not been studied enough. In this regard, the literature review reports limited studies (Lamprey & Boateng, 2017; Okai-Ugbaje et al., 2022). In this sense, some research suggests that the effective

and efficient use of mobile technologies in the educational context may be associated with students' perceived self-efficacy, academic procrastination, and cognitive style.

With respect to the perception of academic self-efficacy, studies show that when faced with the development of a learning task, people make judgments about their level of confidence in terms of their ability to obtain a desired result. Most studies indicate that the level of confidence that a person has regarding developing a task has a direct influence on the choice to participate actively, the effort they will invest and the persistence they will deploy in developing it (Bandura & Locke, 2003). In the field of computer-based learning environments, it is possible to also talk about computer self-efficacy, which can be defined, in general, as the beliefs that people have about their abilities to efficiently use different digital technologies in synchronous and/or asynchronous learning processes (Artino & McCoach, 2008; Compeau & Higgins, 1995; Zimmerman & Kulikowich, 2016).

Therefore, the perception of computer self-efficacy that students have when participating in courses aided by mobile technologies is set as an analysis variable that will allow the academic community to understand and explain student behavior when studying m-learning courses (Kumar et al., 2020; López-Vargas et al., 2020; Yorganci, 2017; Zimmerman & Kulikowich, 2016).

Regarding academic procrastination, this is defined as a student unjustifiably and intentionally postponing the development and completion of academic tasks (Abdollahi et al., 2020; Melgaard et al., 2021; Wang, 2022). Thus, procrastination in the educational context has gained increasing relevance in recent years in the eyes of educators and researchers because it is one of the main indicators of school dropout. Some studies show that procrastination is associated with low levels of self-efficacy, bad time management habits, low capacity for self-regulation of learning and poor academic performance, among others (Abdollahi et al., 2020; Melgaard et al., 2021; Wang, 2022).

In this research field, there is a lack of studies that analyze the impact of procrastination on high school students (teenagers) (Asri et al., 2017; Dienlin & Johannes, 2020; Reinecke et al., 2018). In addition, there is a need for studies looking for possible relationships between procrastination and the use of m-learning environments. The results may help the academic community to design and implement this type of scenario as an innovative educational practice.

Now, regarding a student's cognitive style, especially in the dimension of Field Dependence-Independence (FDI), most research indicates that students who are field-independent (FI) use computer-based learning environments more efficiently and effectively and obtain better learning achievements than their Field Dependent (FD) peers, who exhibit some difficulties when interacting with hypermedia computational scenarios. FI students are more autonomous when interacting with these scenarios, work individually and prefer non-linear navigation. FD learners, on the other hand, prefer guided navigation, work better collaboratively and prefer linear navigation (Chen & Macredie, 2002; Chuang et al., 2021; López-Vargas et al., 2017).

In this research field, there are some studies that discuss a possible association between students' cognitive style and perceived academic self-efficacy when novices interact with computer-based learning environments. According to some studies, it is possible to assert that FI students have a higher level of confidence in their abilities to perform academic tasks in computer-based environments, while their FD peers have low

levels of confidence about their possible performance in this type of environments (DeTure, 2004; López-Vargas et al., 2020; Valencia-Vallejo et al., 2018, 2019).

Finally, other studies indicate that the use of computational scaffolding can benefit subjects' performance when undertaking learning tasks autonomously in computational scenarios (Belland et al., 2013; Huertas et al., 2017; Zhang & Quintana, 2012). In this vein, when a motivational scaffolding is designed and implemented in online scenarios, it constitutes an example of supporting novices to achieve a desired performance and, to some extent, it is possible to favor beliefs in their learning ability through m-learning environments considering individual differences (López-Vargas et al., 2020; López Vargas et al., 2022; Valencia-Vallejo et al., 2018).

Despite the results found by different researchers. They are inconclusive and there is a lack of consensus within the academic community regarding the innovative use of m-learning scenarios addressing students' individual differences. Indeed, the studies are in their initial stages and consequently, further research is needed to comprehend, as well as explain, the actions of students having differing cognitive styles when learning with mobile technologies.

It is also necessary to conduct research that considers both academic procrastination and the perception of online and academic self-efficacy when high school students interact with mobile technologies because this type of study is limited at this educational level. In this sense, it would be key to determine whether the use of m-learning environments that include computational scaffolding represents a potential pedagogical and/or didactic strategy to favor learning achievement. Likewise, and equally important, evaluate if they can positively influence self-efficacy, as well as reduce academic procrastination for students having differing cognitive styles.

On this basis, this research aims to provide insight on:

RQ1: How does a motivational scaffolding affect academic self-efficacy, online self-efficacy, procrastination and learning achievement in high school students learning math through mobile learning?

RQ2: Does learning achievement, online self-efficacy, academic self-efficacy and procrastination differ between subjects, with differing cognitive styles in the dimension of Field Dependence/Independence, in mobile learning?

RQ3: Is there a significant interaction between cognitive style and the use of motivational scaffolding in an m-learning environment on academic self-efficacy, online self-efficacy, procrastination and learning achievement?

2. Conceptual framework

2.1. Self-efficacy in computational environments

Self-efficacy means the judgments people have of their own skills in order to plan, as well as take the necessary steps when developing a specific task (Bandura & Locke, 2003). In the educational field, research shows that students who have high levels of self-efficacy achieve higher academic performance than those students who do not trust their own abilities. These students can plan and manage their own learning process more efficiently. Similarly, when faced with different difficulties when developing tasks, they are more

persistent in achieving goals and, if needed, are willing to make more of an effort to overcome such obstacles (Schunk, 1991; Zimmerman et al., 1992).

In the context of education and information technologies, self-efficacy studies the perceptions that students have regarding the efficient use of different computational scenarios to learn synchronously and/or asynchronously (Artino & McCoach, 2008; Compeau & Higgins, 1995; Zimmerman & Kulikowich, 2016). Most studies assert that the perception of self-efficacy towards the use of information technologies is a decisive factor for people in using m-learning environments in learning processes (Alsarayreh & Aljaafreh, 2023; Kumar et al., 2020; Phan, 2023; Razzaq et al., 2018; Yorganci, 2017). Although there are some studies on the subject in undergraduate students, their results are not definitive or conclusive; hence, the need for further research to provide knowledge on the potential that m-learning environments can have when high school students interact with this type of scenarios.

2.2. Cognitive style in the dimension of field dependence-independence (FDI) and digital environments

Cognitive style is a set of inherent characteristics that define and make a person unique. Initially, this notion denoted those information processing habits representing typical ways in which a novice perceived, thought, remembered, and solved a problem. Subsequently, cognitive style refers to individual differences and personal tendencies in subjects' cognitive organization. Eventually, the cognitive style represents the way an individual finds meaning in their environment (Chuang et al., 2021; Hederich & Camargo, 2015; Nori et al., 2023).

Cognitive style can be defined based on four basic features: (1) it has a differentiating nature as it allows identifying individual conduct; (2) it evidences a certain degree of permanence and therefore the style is stable; (3) an integrating attribute as it includes the different dimensions of an individual; and (4) a neutral nature, i.e., no style is superior to another (Hederich & Camargo, 2015).

Cognitive styles can generally be perceived as a continuous, usually bipolar, system; people at each pole possess perceptual, analytical, intellectual, social, and emotional characteristics that contrast with those possessed by people at the opposite pole, and in between polarities there are countless intermediate points where characteristics from both poles mix. Thus, each individual's cognitive style is located on a point of that continuum (Chen & Macredie, 2002; Hederich-Martínez et al., 2023; López-Vargas et al., 2017; Valencia-Vallejo et al., 2019).

Cognitive style has several classifications. For example, there are impulsive/reflective (Kagan, 1966), holistic/serialist (Pask, 1976), leveling/sharpening (Holzman & Klein, 1954), and field dependence and independence (Witkin et al., 1977) cognitive styles, among others.

In the educational context, probably, the most studied cognitive style is the one referred to as Field Dependence-Independence (FDI), created by Witkin et al. (1977). In the field of information technologies applied to education, research on cognitive style in the FDI dimension systematically shows that students called field-independent (FI) perform better than their field-dependent (FD) peers when interacting with computational environments. Studies assert that FDI novices prefer the study material to be organized in

a sequential (linear) way, navigate the digital scenario together as a group and be guided by other people (Chen & Macredie, 2002; Handal & Herrington, 2004).

In contrast, FI novices prefer navigating freely throughout the computational environment's structure, which results in them performing effectively in hypermedia environments. They can establish navigation paths in an organized manner, are not easily distracted by irrelevant information, and make good use of most of the resources available in the computational environment. Similarly, they like to work individually (Chen & Macredie, 2002; Chuang et al., 2021).

In this field of research, it is possible to positively relate certain stylistic characteristics of field-independent students with their motivational variables, including intrinsic goal orientation and self-efficacy (López-Vargas et al., 2011). On the other hand, some studies have shown that FI novices exhibit greater self-efficacy compared to those who are intermediate and FD (DeTure, 2004).

2.3. Procrastination and digital environments

Procrastination, in the educational context, can be defined as the student, voluntarily and unnecessarily, postponing the completion of assigned tasks thus exposing themselves to negative consequences that may affect their academic performance and increasing the likelihood of dropping out of the educational system (Cerezo et al., 2017; Solomon & Rothblum, 1984; Svartdal et al., 2020). Different studies have shown that in traditional learning environments, the use of procrastinatory behaviors in undergraduate students is common behavior (Cerezo et al., 2017; Svartdal et al., 2020). However, research on procrastination in computer-based learning environments is limited. In this regard, it posits that procrastination behaviors in students may increase in distance learning environments and may be related to high dropout rates in online learning environments (Cerezo et al., 2017; Tuckman, 2005). In addition, it asserts that when developing highly complex tasks, students taking online courses tend to procrastinate more compared to tasks with low levels of complexity (Sun & Kim, 2022).

Some studies have found that students who have high levels of procrastination are less successful and their academic performance is lower compared to those students who are self-regulated in learning (Cerezo et al., 2017; Goda et al., 2015). However, further research is needed to broaden the understanding and explanation of academic procrastination when high school students interact with m-learning environments.

2.4. Procrastination and digital environments

The concept of scaffolding means the assistance that another person gives a subject to successfully develop any skill. The intention of scaffolding is to aid novices in successfully completing a lesson, which involves some type of difficulty they must strive to overcome (Wood et al., 1976). In the field of education and communication technologies, computational scaffolding is a type of aid that allows the novice to autonomously interact and execute a task in a computer-based learning environment (Duffy & Azevedo, 2015). Therefore, computational scaffolding is software programs that use tools such as messages, feedback notes and pop-up windows, among others; to activate and stimulate learning, metacognitive processes and student motivation when interacting with computational scenarios (Belland et al., 2013).

To this extent, a motivational scaffolding aims to provide students with structured aid so that they believe more in their abilities and their confidence level increases when independently learning different content through a computer-based learning environment (Belland et al., 2013; López Vargas et al., 2022; Valencia-Vallejo et al., 2018). In this research, a motivational scaffolding was designed and embedded in an m-learning environment to favor the self-efficacy of subjects having differing cognitive styles in the dimension of FDI and decrease thus academic procrastination.

3. Method

3.1. Design

The study followed a quasi-experimental design with previously formed groups of students from a public education institution in Cundinamarca, Colombia. The study's independent variable is the m-learning environment with two values: m-learning environment with motivational scaffolding and m-learning environment without said scaffolding. The study has an associated variable, cognitive style in the FDI dimension: field dependent, intermediate, and independent. Dependent variables of the research are: academic self-efficacy, online self-efficacy, academic procrastination (fear of failure and task aversion) and learning achievement in terms of integer problem solving (test result average). The covariates were: prior learning achievement (mathematics grades from the immediately preceding year), academic and online self-efficacy pretest, and procrastination pretest.

3.2. Participants

The research involved 87 seventh-grade students (52 females and 35 males) from the departmental educational institution (Cundinamarca, Colombia). The age ranged between 12 and 15 years old ($M = 13.34$, $SD = 0.95$). Students worked through mobile learning, including in its structure a motivational scaffolding and another group worked through mobile learning without said scaffolding. It should be noted that the sample of people who participated in this research was limited and, therefore, the results of the study cannot be generalized.

3.3. Materials

M-learning environment. The mobile application was designed on the App Inventor platform, which is a software development environment created by Google Labs, for the development of applications for Android operating systems. The software contains the knowledge domain of operations with integers and was named “*Mathematical World*”. The mobile app is organized into 5 learning units: 1) Introduction of operations, 2) Addition & subtraction, 3) Multiplication, 4) Division, and 5) Problem-solving. The user interface is shown in Fig. 1. To login to the App, follow these steps: 1) Open the mobile application to access the main interface, 2) If you've registered, enter your username and password, and 3) If you're a new user, select “Sign Up” and fill in the required fields.

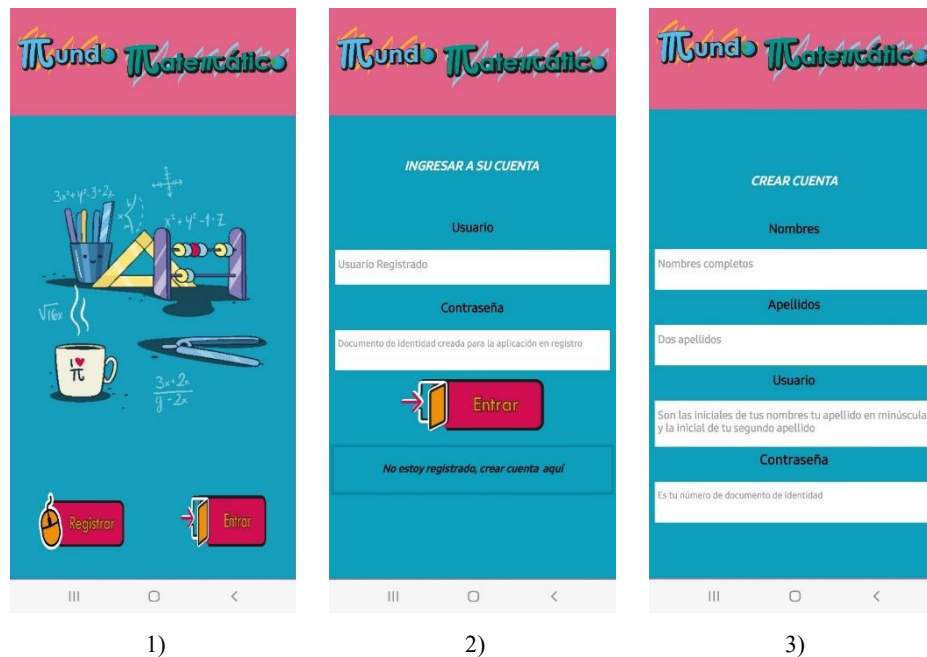


Fig. 1. Interface to login to the m-learning environment “Mathematical World.” The first screen shows the login interface. The second screen shows the login option for registered users. Finally, the screen three shows the login option for unregistered users who can create their own user by filling in the fields provided.

A motivational scaffolding was implemented in its structure to facilitate the development of self-efficacy during the learning process. The scaffolding is comprised of the following stages.

Stage 1: Evaluating prior learning. In this stage, the m-learning environment shows a short reflection, with questions about how students perceive their past learning, as well as their personal efficacy when working out math assignments. This test seeks to make students reflect on what they know now versus what they perceive they previously knew about the topic at hand. Hence, allowing students to be more pragmatic about their skills and setting more feasible learning objectives.

Stage 2: Goal formulation. During this stage, novices must set a learning goal and make a basic strategic plan that will enable them to achieve the chosen goal. The purpose of this stage is that, according to the results of the previous stage, the student chooses a realistic goal. To respect individual differences, a scale of goals was proposed, namely: basic, medium and high. The basic level goals contained simple and straightforward problems. The medium level proposes the solution of problems with a higher degree of difficulty and finally, the high level generates application problems.

Stage 3: Choice self-efficacy judgment. In this stage, the student can make a self-efficacy judgment as they question themselves about the learning goal choice. To this end, the environment offers four alternatives: 1) I feel completely confident I will achieve it, 2) I feel confident I will achieve it, 3) I am not very sure I will achieve it, and, finally, 4) I am completely sure I will not achieve it. This is an operational form that allows the novice to monitor their self-efficacy.

Stage 4: Navigating the environment. The novice can freely navigate the mobile environment. At the top of each unit, the application shows a box with an indication of the chosen goal so that the novice keeps it in mind during the learning process. This facilitates monitoring. Similarly, a self-assessment tool was implemented to facilitate monitoring student learning. Once the student answers the questions, the application informs them whether the answer is right or wrong and a message is issued encouraging them to continue or, on the contrary, congratulate them for their progress.

Some positive feedback messages are: *“You did it, you reached the goal, let's keep going, you can do it!”* *“Good, I'm sure you can handle a higher goal.”* *“Goal achieved. You're doing well, remember there's always room for improvement.”* *“You did not reach your goal, but don't lose spirit, keep studying and you'll achieve it.”* *“Try again, you'll surely achieve it!”* *“You did not reach your goal, invest more time!”* *“Try again, you'll reach your goal.”* among others. The purpose of this tool is to motivate the student repeatedly to achieve the desired learning.

3.4. Instruments

3.4.1. Cognitive style test

The test used to determine cognitive style in the field dependence-independence (FDI), Witkin's Embedded Figures Test (GEFT) was applied. It is a perceptual test that requires the subject to locate a simple figure, previously seen, inside a figure with a complex design. The test contains 18 complex figures. The task is to find the simple figures within a given time. The reliability of the instrument is high (Cronbach's α between .82 to .90) (Witkin et al., 1977). An online version of the instrument has been applied to Colombian students. The test showed a Cronbach's alpha of .847 (Hederich-Martínez et al., 2016). The mean of the GEFT test was 6.45; standard deviation (SD = 3.69). Out of a total score of 18; the lowest possible value was 2 points and the highest was 18 points.

The distribution of the scores obtained by students on the GEFT test is divided into three equal parts, ordered from lowest to highest (Terciles). This allows grouping novices into three groups according to their cognitive style: (1) 28 students who are field-dependent (tercile 1), (2) 28 students who are intermediate (tercile 2), and (3) 31 students who are field-independent (tercile 3).

3.4.2. Subscale of academic self-efficacy according to the MSLQ instrument

Students answered the subscale of academic self-efficacy subscale corresponding to the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al., 1991). This questionnaire falls under the category of self-reporting and is comprised of eight questions that evaluate self-efficacy in terms of academic achievement and learning. It has a Likert scale with seven points (1 = No, never; ...; 7 = Yes, always). It should be noted that this test has been used in investigations involving students from Colombia and it is highly reliable (Hederich-Martínez et al., 2016; López Vargas et al., 2022; Valencia-Vallejo et al., 2018). In this research, the instrument had a Cronbach's alpha of 0.924.

3.4.3. *Online self-efficacy subscale*

The online learning self-efficacy subscale (Online Learning Value and Self-Efficacy Scale – OLVSES) (Artino & McCoach, 2008) was used. It is a self-reporting questionnaire that asks five self-efficacy questions that assess students' confidence in their ability to learn in an environment with mobile technologies. It has a Likert scale with seven points (1 = No, never; ...; 7 = Yes, always). The reliability of the instrument shows high levels of reliability (Cronbach's $\alpha = 0.87$) (Artino & McCoach, 2008; Zimmerman & Kulikowich, 2016). In this research, the instrument had a Cronbach's alpha of .893.

3.4.4. *Academic procrastination scale*

The PASS (Procrastination Assessment Scale Student) scale (Solomon & Rothblum, 1984), a version adapted to Spanish (Garzón & Gil, 2017), was used. It consists of 44 items and is divided into two sections. The first part of the test has 18 items that aim to determine the frequency of procrastination, and the second part consists of 26 items that ask about the reasons for procrastinating. Each question is scored on a five-point Likert scale (1 = never; ...; 5 = always). The subscales of fear of failure and task aversion were used. The validation of the instrument for the Colombian Undergraduate population shows a reliability of .71 to .82 (Garzón & Gil, 2017). In this research, the instrument had a Cronbach's alpha for the fear of failure scale of .779 and task aversion of .776.

3.4.5. *Learning achievement*

Based on the average of five tests, students' learning achievement was calculated (one per lesson). All tests consisted of 5 multiple-choice questions. For this study, the reliability of the tests taken by students is high (Cronbach's $\alpha = 0.83$).

3.4.6. *Procedure*

To conduct the research, the management of the departmental educational institution (Cundinamarca, Colombia) was contacted and accepted the participation of the seventh-grade students in the study. Subsequently, the research proposal was shared with both math students and teachers, and parents were asked for their consent to allow student participation, highlighting the results' confidentiality terms and its investigation objective.

Once informed consent forms were collected, the GEFT masked figures test was applied to the group in the institution's computer lab. Subsequently, the MSLQ academic self-efficacy pretest, OLVSES online self-efficacy and PASS academic procrastination tests were applied, each on a different day. These were administered through a form developed in Google Drive. Next, students were randomly assigned to two groups; one group worked in the m-learning environment with the motivational scaffolding designed especially for this research. The other group worked in the m-learning environment without the scaffolding. Each student had their own smartphone and corresponding internet connectivity.

Subsequently, all students were instructed on the installation, as well as operation, of m-learning environments on their respective smartphones. Next, students interacted in the m-learning environment for five weeks, during the math class schedule.

Once all lessons were completed, 7 days later, participants were given the subscale of self-efficacy corresponding to the MSLQ instrument and OLVSES online self-efficacy scale, PASS procrastination scale, and tests systematized with a Google Drive form.

4. Findings

The databases were organized and validated to ensure the quality of the results. The Statistical Package for the Social Sciences software, version 25, was used. Before performing the corresponding analysis, univariate and multivariate outliers were eliminated (Mahalanobis distance), and the statistical assumptions of normality were validated (skewness and kurtosis values were less than the absolute value of 1.2). At the multivariate level, the homogeneity of the variance-covariance matrices (Box's p -value $M = 0.184$). Likewise, the homogeneity of the regression hyperplanes between the independent variables and the covariates was validated, showing p -values greater than 0.116.

A 2 (m-learning: with scaffolding, without scaffolding) $\times$ 3 (cognitive style: dependent, intermediate, independent) multivariate factorial analysis of covariance (MANCOVA) was performed. Table 1 shows the summary of the descriptive statistics of the dependent variables of the groups of students who worked in the m-learning environment with and without a motivational scaffolding, considering the cognitive style in the FDI dimension.

Table 1

Descriptive data of dependent variables for procrastination

m-learning	Cognitive style	N	FF		TA		AS		OS		LA	
			M	SD	M	SD	M	SD	M	SD	M	SD
With scaffolding	Dependent	15	3.27	0.84	2.93	0.97	5.04	1.06	4.74	0.90	3.14	0.75
	Intermediate	12	2.90	0.60	2.67	0.70	4.84	0.68	4.37	0.69	3.20	0.82
	Independent	15	3.20	0.60	2.87	0.92	4.83	0.65	4.62	0.52	3.05	0.87
	Total	42	3.14	0.69	2.83	0.87	4.91	0.82	4.59	0.72	3.12	0.80
Without scaffolding	Dependent	13	2.91	0.83	3.21	0.69	3.83	1.32	3.96	1.17	2.70	0.73
	Intermediate	16	2.73	0.95	2.31	0.96	5.03	0.76	4.57	0.94	3.24	0.74
	Independent	16	3.01	0.94	2.42	0.99	4.88	0.69	4.47	0.47	3.20	0.80
	Total	45	2.88	0.90	2.61	0.96	4.63	1.05	4.36	0.91	3.07	0.78
Total	Dependent	28	3.10	0.84	3.06	0.85	4.48	1.32	4.38	1.09	2.93	0.76
	Intermediate	28	2.80	0.81	2.46	0.86	4.95	0.72	4.48	0.83	3.22	0.76
	Independent	31	3.10	0.79	2.63	0.96	4.85	0.66	4.54	0.49	3.12	0.82
	Total	87	3.00	0.81	2.72	0.92	4.76	0.95	4.47	0.83	3.09	0.78

Note. FF = Fear of failure; TA = Task aversion; AS = Academic self-efficacy, OS = Online self-efficacy; LA = Learning achievement.

With respect to the variable of use of the m-learning environment, the results of the MANCOVA analysis show significant differences in academic self-efficacy in favor of students who used motivational scaffolding ($F(1, 76) = 6.12, p = 0.016, \eta^2 = 0.075$). Similarly, there are significant differences in online self-efficacy in favor of students who used motivational scaffolding ($F(1, 76) = 5.11, p = 0.027, \eta^2 = 0.063$) (see Fig. 2). The data show that there are no significant differences in procrastination (fear of failure and task aversion) because of motivational scaffolding included in the m-learning environment

($F(1, 76) = 1.86, p = 0.177, \eta^2 = 0.024$) and ($F(1, 76) = 0.013, p = 0.909, \eta^2 < 0.001$) respectively. Likewise, no significant differences were found in learning achievement ($F(1, 76) = 0.19, p = 0.666, \eta^2 = 0.002$).

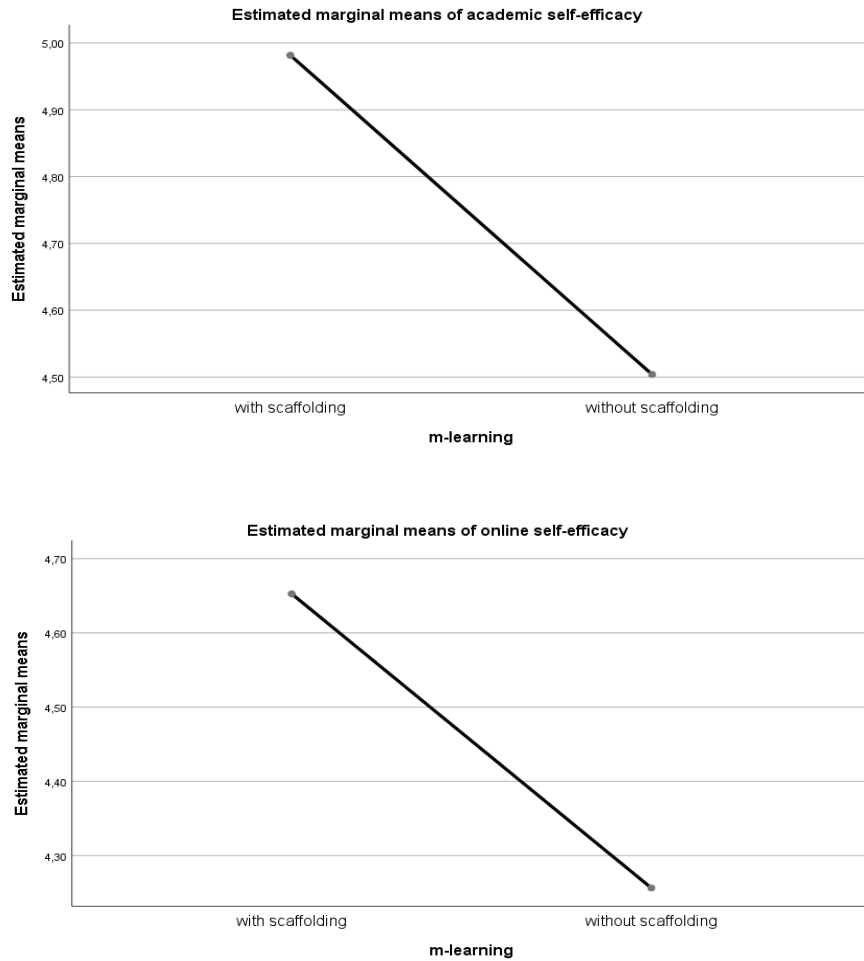


Fig. 2. Motivational scaffolding effects on academic and online self-efficacy

Regarding cognitive style in the FDI dimension, the results showed significant differences in task aversion ($F(2, 76) = 4.17, p = 0.019, \eta^2 = 0.099$). Likewise, there are significant differences in self-efficacy ($F(2, 76) = 3.33, p = 0.041, \eta^2 = 0.080$). The data show that there are no significant differences in the fear of failure variable ($F(2, 76) = 0.58, p = 0.561, \eta^2 = 0.015$), there are also no significant differences in online self-efficacy ($F(2, 76) = 1.18, p = 0.312, \eta^2 = 0.030$) and academic success ($F(2, 76) = 1.09, p = 0.341, \eta^2 = 0.028$).

Finally, regarding the interaction between m-learning environment and cognitive style in the dimension of FDI, the data show there are significant differences in self-efficacy ($F(2, 76) = 5.16, p = 0.008, \eta^2 = 0.119$) and online self-efficacy ($F(2, 76) = 5.63, p = 0.033, \eta^2 = 0.086$). There are no significant differences in the variables of fear of failure

($F(2, 76) = 0.25, p = 0.782, \eta^2 = 0.006$), task aversion ($F(2, 76) = 1.49, p = 0.232, \eta^2 = 0.038$) and academic success ($F(2, 76) = 0.42, p = 0.661, \eta^2 = 0.011$).

A Bonferroni post hoc analysis indicated that considering cognitive style in the FDI dimension, there are statistically significant differences in task aversion ($p < 0.05$) between FD students ($M = 3.06, SD = 0.85$) and field intermediate students ($M = 2.46, SD = 0.86$). Significant differences were also observed in academic self-efficacy ($p < 0.05$) between FD students ($M = 4.48, SD = 1.32$) and, between intermediate and FI students ($M = 4.95, SD = 0.72$) and ($M = 4.85, SD = 0.66$), respectively (see Fig. 3).

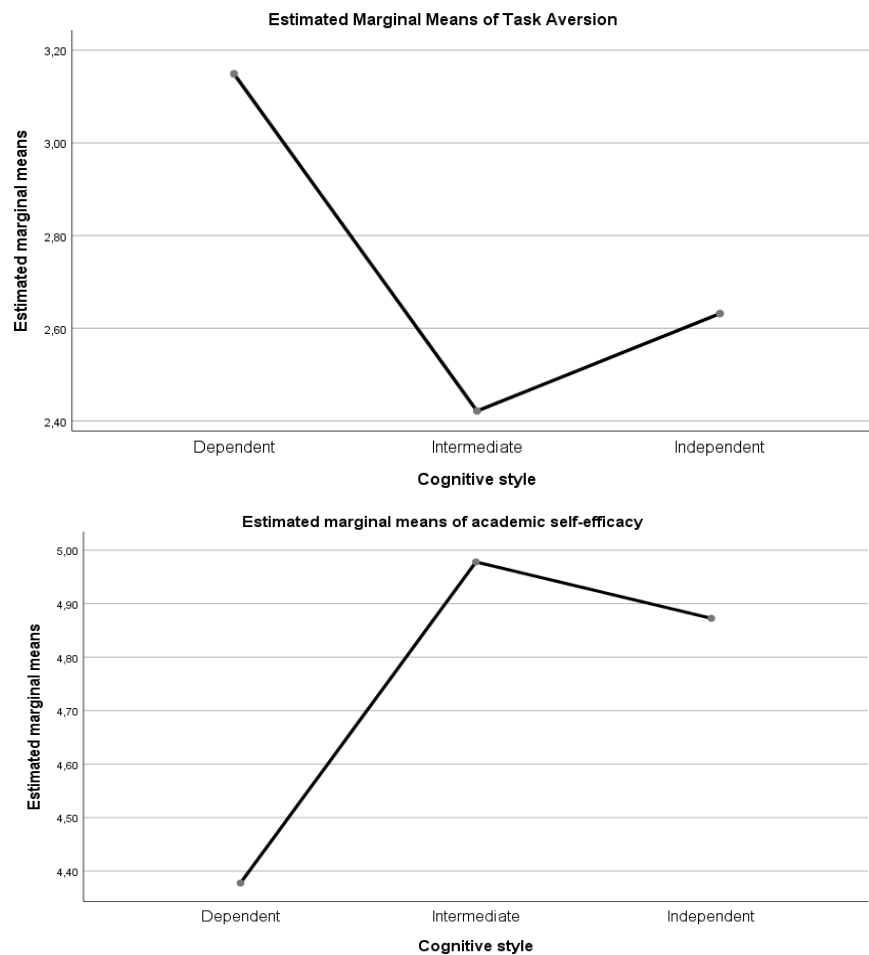


Fig. 3. Effect of cognitive style on procrastination (task aversion) and academic self-efficacy

On the other hand, the Bonferroni post hoc, in the interaction of m-learning environment $\times$ cognitive style in the FDI dimension, shows statistically significant differences in academic self-efficacy ($p < 0.05$) between FD students who use motivational scaffolding ($M = 5.04, SD = 1.06$) and FD students who do not use scaffolding ($M = 3.83, SD = 1.32$). Significant differences in online self-efficacy ($p < 0.05$) are also observed between FD students using the motivational scaffold ($M = 4.74, SD = 0.90$) and, between FD students not using the scaffolding ($M = 3.96, SD = 1.17$) (see Fig. 4.).

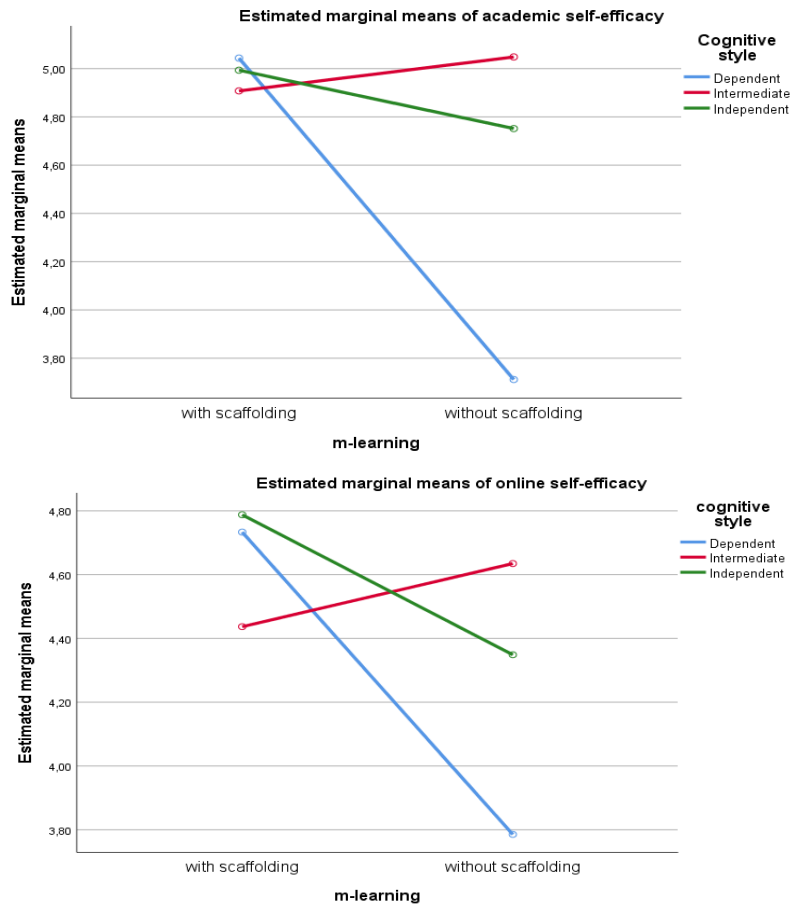


Fig. 4. Interaction between motivational scaffolding and cognitive style on academic and online self-efficacy

5. Discussion

Considering the research questions and hypotheses that guided this research, the following discussion is had.

Regarding the first research question, the results of the study show that a motivational scaffolding for mobile learning beneficially impacts academic and online self-efficacy. In this sense, the design of the scaffolding enables students to increase their assuredness in their skills to reach the sought-after success in math. The scaffolding aims to aid the student in their performance while respecting their learning pace and individual differences.

The proposed scaffolding increasingly presents the student with goal achievements so that they experience positive learning processes; a fact that leads to a positive increase in their perceived self-efficacy, both academic and online, in learning math. This work dynamic allows the novice to gain confidence in their abilities in a differential way

according to their cognitive style. Undoubtedly, this pedagogical and/or didactic strategy would be a way to stimulate the learning of mathematics through mobile technologies and, it also constitutes a potential tool that would be able to promote self-regulation of learning (Broadbent et al., 2020; Jenó et al., 2019; Zhang & Quintana, 2012; Zheng et al., 2018).

The designed scaffolding contains learning self-assessment modules, in addition, it displays motivational messages to encourage students to strive and be persistent in achieving self-imposed goals. In this sense, it is possible to assert that providing novices with feedback that favors their perception of personal efficacy can be very useful in autonomous learning. These findings constitute empirical evidence that supports, to a certain extent, research investigating implementations of motivational scaffolding to benefit self-efficacy, performance, as well as self-regulation of learning in computer-based environments (López-Vargas et al., 2020; López Vargas et al., 2022; Valencia-Vallejo et al., 2018). In this line of work, these findings support the results of studies that used m-learning environments to favor academic, online self-efficacy and learning achievement (Kumar et al., 2020; López-Vargas et al., 2020; Razzaq et al., 2018; Yorganci, 2017). These results allow partial validating of the first of the working hypotheses since self-efficacy is indeed favored. However, there are no significant differences in academic procrastination between both groups of students who interacted with the m-learning environment with and without motivational scaffolding.

Regarding the second question this research sought to answer, findings show that academic success does not differ between students having differing cognitive styles in the dimension of FDI. That is, FI, intermediate and FD students achieved equivalent learning when learning math content aided by mobile technologies. The results of the study support the hypothesis that scaffolding facilitates achieving more equitable knowledge and in this sense, it is possible to assert that it can be an interesting pedagogical and/or didactic strategy, insofar as it eliminates the trends found in most studies in which FI students always perform better than their intermediate and FD peers in traditional learning environments in math and science (Hederich-Martínez et al., 2016; Huertas et al., 2017; López-Vargas et al., 2020; López Vargas et al., 2022; Solórzano-Restrepo & López-Vargas, 2019; Valencia-Vallejo et al., 2019).

On the other hand, the results show that field-dependent students have a lower perceived self-efficacy than their intermediate and FI peers. This finding is consistent with other studies that found that field-dependent students, due to their stylistic characteristics, are not confident in their ability to learn math and therefore, do not try hard enough nor dedicate the necessary time to obtain the desired learning (López-Vargas et al., 2011; López-Vargas & Triana-Vera, 2013; Valencia-Vallejo et al., 2018). However, it should be noted that in this study no significant differences in online self-efficacy between students with different cognitive styles were found. This finding is promising insofar as scaffolding would be able to aid FD students in the effective and efficient use of mobile technologies. The use of scaffolding can become an interesting pedagogical and/or didactic strategy for this type of student because it can generate autonomy in their learning process.

Although these results are inconclusive, it is possible to assert that they are promising because motivational scaffolding can be interesting insofar as it favors the learning of FD students; however, it is necessary to deepen the design and implementation of these in m-learning scenarios (López-Vargas et al., 2020; López Vargas et al., 2022; Valencia-Vallejo et al., 2018).

As it relates to the issue of academic procrastination, the study shows that FD students present higher levels of task aversion compared to their intermediate and FI peers. A possible explanation for this finding may be related to the stylistic characteristics of FD students, who are characterized by processing information holistically and, in this sense, exhibit deficits in the selection and implementation of learning strategies for the execution of tasks that require selective attention to relevant cues. Likewise, they exhibit difficulties in tasks that require breaking down a whole into its different parts (analytical processing). At the same time, they are characterized by low skills in restructuring information and cognitive strategies that are essential to learning math. On the other hand, FD students prefer to work collaboratively and be assisted when interacting with computational environments (Chen & Macredie, 2002; Chuang et al., 2021; Hederich & Camargo, 2015; López-Vargas et al., 2011).

In this order of ideas, FD students, when faced with learning tasks in mathematics may have feelings of refusal to learn and thus, tend to postpone the learning process, completion and submission of tasks. This behavior of FD students, to a certain extent, may be associated with their low levels of perceived academic self-efficacy since they lack confidence in their abilities to take on the challenge of learning math. In addition, learning with mobile technologies requires high levels of autonomy to work individually. To this extent, FD individuals may have a tendency toward academic procrastination. Therefore, it is plausible to state that there is a coincidence between the stylistic characteristics of FD students, procrastination (task aversion) and low perceived academic self-efficacy in learning mathematics when learning mathematical content through mobile technologies.

Finally, regarding the third research question, the results suggest a significant interaction between the m-learning environment and cognitive style in the dimension of FDI. Based on the results, FD students benefit from using mobile technologies that include motivational scaffolding that favors academic and online self-efficacy. This finding is promising to the extent that students with different cognitive styles in high school can consider mobile technologies that include motivational scaffolding as an innovative tool to enhance or favor their learning process while respecting their individual differences. Thus, they would be able to use their smartphones as innovative scenarios where they can access content and study materials from anywhere and at any time, given their connectivity characteristics. These results validate the fourth of the working hypotheses.

6. Conclusion

Based on the study's results, it is possible to conclude that the use of a motivational scaffolding in an m-learning environment interacting with a student's cognitive style in the dimension of FDI, significantly favors FD students' academic and online self-efficacy. Also evidenced is that the use of motivational scaffolding helps to positively reduce individual differences in academic success of students having differing cognitive styles in the dimension of FDI. Similarly, it is permissible to assert that FD students show high levels of procrastination in terms of task aversion compared to their intermediate peers and, in turn, show a lower perceived academic self-efficacy than their intermediate and field-independent peers. In this order of ideas, it would be advisable to promote, in high school, the use of m-learning environments that incorporate motivational scaffolding that respects students' individual differences. Likely, the use of this pedagogical strategy may induce novices to use mobile technologies as a learning scenario where they can achieve the desired performance.

However, further research is needed to understand and explain the behavior of high school students when they interact with learning environments aided by mobile technologies.

7. Limitations and further research

The study was a quasi-experimental research since the groups that participated in the study were previously organized and were not randomly constituted; this does not allow for generalizing the results. It would be convenient to increase the sample of students since in this study the number of participating students was limited. Having a sufficiently large sample and, in addition, organizing the groups randomly to conduct an experimental study would allow generalizing the results and providing greater empirical evidence.

On the other hand, the instruments that have been used to measure procrastination and academic and online self-efficacy are based on self-reporting. It would be important to have additional indicators that would make it possible to account for student behavior more objectively in these variables.

Author Statement

The authors declare that there is no conflict of interest.

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