Characterization of Self-Regulation of Learning as an Executive Function in Students Within Virtual Learning Environments

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Abstract

Virtual Learning Environments (VLE) are part of the academic offerings of higher education institutions, defined as the space created through information and communication technologies where a series of environments converge to facilitate analysis, reflection, and appropriation of knowledge (Ramírez García et al, 2021). In these environments, self-regulation of learning is relevant for satisfactory academic performance. Self-regulation is a process by which students control their thoughts, actions, and emotions to achieve specific learning goals (Zimmerman et al., 1996). Executive functions are cognitive skills that allow planning, organization, decision-making, and impulse control, which are fundamental for effective self-regulation (Barkley, 2012). The purpose of this study is to characterize the profile of self-regulation, as an executive function, in graduate students and executive careers participating in Virtual distance education at a university located in northwestern Mexico. The project was developed following a non-experimental methodology, a quantitative approach, correlational and cross-sectional scope. Two assessment instruments were used: the Behavior Rating Inventory of Executive Function, Self-Report (BRIEF-A) and the Motivated Strategies for Learning Questionnaire (MSLQ). This paper presents the results of the first of two phases, which consisted of a pilot test of the BRIEF-A instrument with 71 students, obtaining relevant information on executive functions related to planning, organization, self-monitoring and metacognition.

Keywords: Self-Regulation, Online Learning, Executive Functions, Higher Education

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Introduction

In the contemporary educational context, the growing prevalence of distance education poses significant challenges and opportunities for effective learning. In this sense, the issue of self-regulation strategies (SRA) in virtual environments becomes relevant, as this skill is positioned as a crucial ability for students to optimize their learning process. The ability of students to manage their own cognitive, emotional and behavioral resources becomes a determining factor in achieving academic success in these contexts (Cabrero-Almenara & Palacios-Rodríguez, 2021).

One of the fundamental purposes of contemporary higher education is to encourage students to become active agents capable of self-regulating their own learning process. Facilitating the formation of competencies that enable students to learn autonomously is perceived as one of the significant challenges of today's university, as pointed out by Cerezo et al. (2015) in Castro, Suárez and Rivera (2021).

Vélez-Torres (2023) states that in recent years, distance education has increased the offer of diverse online courses. University students have chosen this modality due to the advantages it offers. In response to this trend, institutions provide students with educational tools that give them academic and professional preparation to access better job opportunities. In particular, for graduate students, this offer allows them to update themselves in the work environment, in order to improve their quality of life.

However, it is observed that most students are not properly equipped to meet the requirements demanded by a distance education, since they lack self-regulation skills (Schober et al., 2015, as cited in Saez et al., 2018). The absence of these competencies to manage the learning process constitutes a fundamental element in cases of low academic performance in Higher Education, studies have found that in order to decrease dropout it is essential to address and mitigate the frustrating experience that students may feel due to problems related to the virtual environment, as well as situations related to the self, technical, academic or economic factors (La Madriz, 2016).

Therefore, it is expected that the graduate student, who participates in distance studies, has significant control over his learning process. In order to further explore this dynamic, the present study will focus on analyzing how students self-regulate their learning process in virtual environments with the purpose of elaborating a profile of them, as a first step to support them in this process.

Feo (2013) emphasizes that in the context of virtual environments, it is the student who must become aware of the need for autonomous, independent and self-directed learning, according to the demands of the study environment in which he/she finds him/herself. In conclusion, it is emphasized that in the distance modality it is feasible to incorporate face-to-face meetings mediated by printed and/or technological devices, which can complement or explain a process or information that has been initiated at a distance, thus facilitating learning to be genuinely meaningful.

A necessary element to consider is the relationship of ARA with academic performance (Dieser, 2016). Since this element is manifested in the direct influence it has on school dropout (Velázquez et al., 2017) and academic failure (Gilar-Corbi et al., 2020), both in face-to-face and virtual environments (La Madriz, J., 2016). Given the importance of

understanding and addressing these phenomena, it is essential to further examine the protagonist role assumed by the student in virtual environments, as pointed out by Rizo-Rodríguez (2020). This protagonism requires a significant willingness to address both individual and shared activities and work.

According to data from the National Institute of Statistics, Geography and Informatics (INEGI), of the population enrolled in the 2021-2022 cycle, 60.5% of higher education students were enrolled in distance mode. As for the hybrid modality, 26.8% of the students were enrolled. In relation to the media used for classes, the most used were virtual classes 62% and virtual platforms 60.5%.

La Madriz (2016) states that the challenge to be faced by virtual learning environments, in their effort to decrease the dropout rate among users, is to encourage students to develop the ability to discern, analyze and evaluate the content they are learning, instead of merely being passive consumers of the information available on the network.

Regarding school dropout data with respect to distance education in Mexico, Statista (2023) states:

> In the case of higher education, which includes universities and other technical and vocational education institutions, it is estimated that at least 305,000 students stopped attending classes. This represents 8% of the student body. According to a survey conducted between April and May 2020, almost two-thirds of the university students surveyed in Mexico were enrolled in face-to-face programs.

According to the Regional Monitoring Report SDG4-Education 2030 published by UNESCO, UNICEF and ECLAC (2022), progress towards achieving education for all throughout life in Latin America is in a complex situation, due to the fact that the educational goals for the five-year period from 2000 to 2015 have not been met. At the same time, the effects of the pandemic and the need to meet the goals foreseen for 2030 generated important tensions that have compromised educational equity and quality education, in part generated by the transfer to the virtual environment without adaptation periods (Huerta-Estévez et al., 2023).

Among the factors that best explain academic performance are those related to the way in which students study and learn (González-Pienda, 2003), set goals, manage their time, that is, the way in which they manage their learning (Panadero, 2014). Thus, Self-Regulation of Learning (SRL) in recent decades has received increasing attention in terms of its promotion in students, since it enables not only better academic results, but also greater autonomy and motivation, a clear protagonism in their learning process and a necessary ability to transfer to different situations. Therefore, it is relevant that the graduate student acquires autonomy, understands his cognitive processes and develops the ability to regulate his learning process (Torrano et al., 2017), in the virtual environment.

Justification

In this scenario, the present research is considered to have different contributions. Regarding its theoretical contribution, it contributes with inputs to the analysis of academic performance and its relationship with ARA and executive functions of students in a private subsidized school.

Therefore, it is relevant to characterize the profiles of students in virtual environments, which will allow the development of attention programs that assist students to improve their ARA. According to Gaeta et al, (2016) when students feel competent to self-regulate their learning, their motivation towards study and academic performance improves.

Regarding the practical and social implications, the findings of the study will provide students, teachers and school authorities with a specific profile of graduate students in virtual environments, as well as resources for the development of ARA training programs from an integrative perspective, not only for students, but also to promote its implementation from the teaching practice. In addition, by evaluating students' ARA strategies, it is possible to understand what are the current practices? Identify areas for improvement, promote effective learning and personalize support, providing support for strategies that will lead them to a more successful academic performance and to complete their studies by improving their ability to direct and control their own learning in virtual environments.

State of the Art

University Education in Virtual Environments

Distance education is an educational approach in which the student is in a geographically separate location from the teacher. It can be employed independently or combined with other educational modalities, including face-to-face contact. In this method, students are physically away from the educational institution (Simonson et al., 2015, p. 34).

Rodríguez León and Alonso Núñez, citing UNAM, define distance education as "an asynchronous teaching and learning model, through a computer and educational platform" (Universidad Nacional Autónoma de México [UNAM], 2013, p. 6).

In a virtual environment, Rizo-Rodriguez (2020), points out that the role of the university student acquires a role in which the need for considerable willingness to actively participate in both individual and collaborative activities is highlighted, in addition, he emphasizes the importance of student autonomy to develop fundamental technological skills to acquire knowledge and professional competencies, the capacity for self-management, which is manifested in self-discipline, self-learning, critical and reflective analysis, as well as collaborative work.

Self-Regulation of Learning

Self-regulation of learning (SRL) is a process through which the student controls and directs his/her own learning, incorporates cognitive, affective, metacognitive and motivational aspects, and also involves social issues by requesting help and support from others (Panadero, 2014). In higher education, ARA is a key term given that it promotes student autonomy by eliciting competencies that favor academic performance (Barrios et al., 2017). Although self-regulation is linked to health management, stress control, and even to less complex processes such as the performance of routines, it also includes the use of tools that allow describing how people monitor and adjust their own cognitive processes in the educational context (Zeidner et al., 2000 as cited in Puustinen & Pulkkinen, 2001).

The description of ARA that has had the greatest consensus among experts on the subject is understood as "the control that the subject performs over his/her thoughts, actions, emotions

and motivation through personal strategies to achieve the goals he/she has established" (Panadero & Tapia, 2014, p. 451) in academic situations, such as preparing for an evaluation or performing school tasks (Zimmerman & Schunk, 2011, as cited in Trías and Huertas, 2020). Thus, ARA is a process of reflection and action through which the student organizes, monitors and evaluates his or her learning; it is related to greater appropriation of content, more engaged participation in studies and higher academic performance (Trías & Huertas, 2020).

Executive Functions

It is essential to understand the level of development of executive functions in the student population and to strengthen those areas, skills or specific dimensions within these functions that present low levels of development. To some extent, the academic success of students depends on this strengthening (Cascante et al., 2015).

Executive functions have been investigated in the field of neuropsychology, providing valuable knowledge that enriches various scientific and professional disciplines. In the educational field, the application of this neuropsychological knowledge is significant, as it contributes to improve educational processes to achieve effective learning in students. This is especially relevant given that executive functions play a crucial role in control, regulation and planning, allowing people to engage in and successfully complete various actions (Lezak, 1994, cited by Flores & Ostrosky-Shejet, 2013).

Executive Functions: Concept

Moret and Mazeau, 2013 (cited in Soprano, 2014) state that the meaning of executive functions (EFs) has not been clarified or agreed upon, however the approaches to it, define it as the set of abilities of direction, control and regulation of cognitive processes, emotions and behavior that are used to solve problems in an appropriate way, in the face of the events that arise. "Evidently it is a heterogeneous construct, with a broad spectrum and imprecise limits, with frequent overlaps with functions belonging to other domains of the cognitive area, as well as emotional, and which can also have a fairly distant relationship with each other" (p. 102).

The literature identifies more than twenty EFs: organization, planning, anticipation, inhibition, working memory, flexibility, verbal fluency, visual fluency, self-monitoring, common sense, creativity, metacognition, behavioral regulation, emotional control, and several others (Soprano, 2014).

Methodology

The present study corresponds to a non-experimental research, with a quantitative, cross-sectional and correlational method design. The project was developed in 12 months, divided into 2 stages. The first part was the application of the BRIEF-A pilot test to higher education students.

The study group consisted of students from the School of Business and Management and the School of Engineering (N=71), of which 42 % were female, 55 % were male and 3 % preferred not to answer. The participants were chosen by non-probabilistic sampling.

Participation was anonymous and voluntary, without compensation, and they had the option to withdraw from the study at any time.

The instrument was administered through Google Forms, and the responses were compiled in Google Sheets, ensuring that only the research team had access to the information. For data analysis, Microsoft Excel and JASP, an open access software specialized in statistical analysis, were used.

Research Instrument

The Behavioral Rating Inventory of Executive Function-Adult Version (BRIEF-A) is a standardized self-report measure that captures adults' views of their own executive functions, or self regulation, in their everyday environment. It is designed to be completed by adults between the ages of 18 and 90 years (2005).

The BRIEF-A is composed of 75 items within nine theoretically and empirically derived clinical scales that measure different aspects of executive functioning: Inhibit, Shift, Emotional Control, Self-Monitoring, Initiative, Working Memory, Plan/Organize, Task Monitor, and Organization of Materials. Also the clinical scales form two broader indexes: The Behavioral Regulation Index (BRI) and the Metacognition Index (MI) and an overall summary score, the Global Executive Composal (GEC).

The following is a description of the scales, indices and overall score according to the application manual:
1. Inhibit measures the respondent's inhibitory control, is the ability to resist impulses and the ability to stop one's own behavior at the appropriate time.
2. Shift is the ability to make transitions, tolerate change and move freely from one situation, activity or aspect of a problem to another.
3. Emotional control reflects the influence of the executive functions on the expression and regulation of one's emotion.
4. Self-monitor measures a personal self-monitoring function-the extent to which the adult keeps track of his or her own behavior and the effect on others.
5. Initiate scale contains items relating to beginning a task or activity and to independently generating ideas, responses, or problem solving strategies.
6. Working-Memory measures the respondent's capacity to actively hold information in mind for the purpose of completing a task or generating a response.
7. Plan/organize measures the adult's ability to manage current and future-oriented task demands within the situational context.
8. Task monitor measures a problem-solving, task-oriented, monitoring function to the extent to which the individual keeps track of their own problem solving success or failure.
9. Organization of materials places a greater emphasis on the cognitive task-oriented aspects of organization, measures organization in the adult's everyday environment with respect to orderliness of work, living and storage spaces.

The Indexes and the Global Executive Composite

Behavioral Regulation Index (BRI), represents the adult's ability to maintain appropriate regulatory control of his or her behavior and emotional responses.

Metacognition Index (MI), represents the individual's ability to systematically solve problems via planning and organization while sustaining these task-completion efforts in active working memory.

Global Executive Composite is a summary score that incorporates all of the clinical scales of the BRIEF-A.

Table 1 describes the indicators for the interpretation of the results obtained in BRIEF-A, where a high score means difficulties in executive function.

Table 1: Interpretation of T-scores in BRIEF-A

T Score Range	Interpretation
65 or higher	Suggests a high level of difficulty in the specific area, potentially indicating issues with executive functioning.
Below 65	Indicates a more adaptive or normative level of functioning.

Basuela (2016) studied the internal consistency of the Spanish version of the BRIEF-A, concluding that it is "valid and reliable for the assessment of executive functions in adulthood" showing correspondence with the original version of the instrument. In the study they found a high internal consistency (Cronbach's $\alpha = 0.841$).

This part of the study presents analysis and interpretation of the data of the study from the consolidated results of the pre-test.

The results of the pilot test applied to 71 university students are presented below. Beginning with the descriptive statistics and general data of the participants (Table 2), the average age was 18.74 years, indicating that most of them are beginning their university studies.

Fifty-five percent of the participants were male and 43% were female.

Table 2: Descriptive Statistics and Gender

Age	
Mean	18.74
Std. Deviation	1.024
Minimum	18
Maximum	23
Genre	
Fluid gender	1%
Prefer no to answer	1%
Feminine	43%
Masculine	55%

Forty-six percent belonged to a career related to the Business Administration school and 54% were enrolled in an engineering academic program.

Table 3: Type of Academic Program Enrolled

Business Administration	46%
Engineering	54%

The results obtained indicate a solid functional performance in the evaluated areas. The BRI and MI indexes present values that reflect balanced functional abilities in behavioral regulation and metacognition. Likewise, the global index of executive functions (GEC) reached a positive overall level in the management of these abilities. This suggests that students have adequate competencies to regulate their behaviors, plan and solve problems effectively. Overall, the results show a good level of development in the executive functions evaluated.
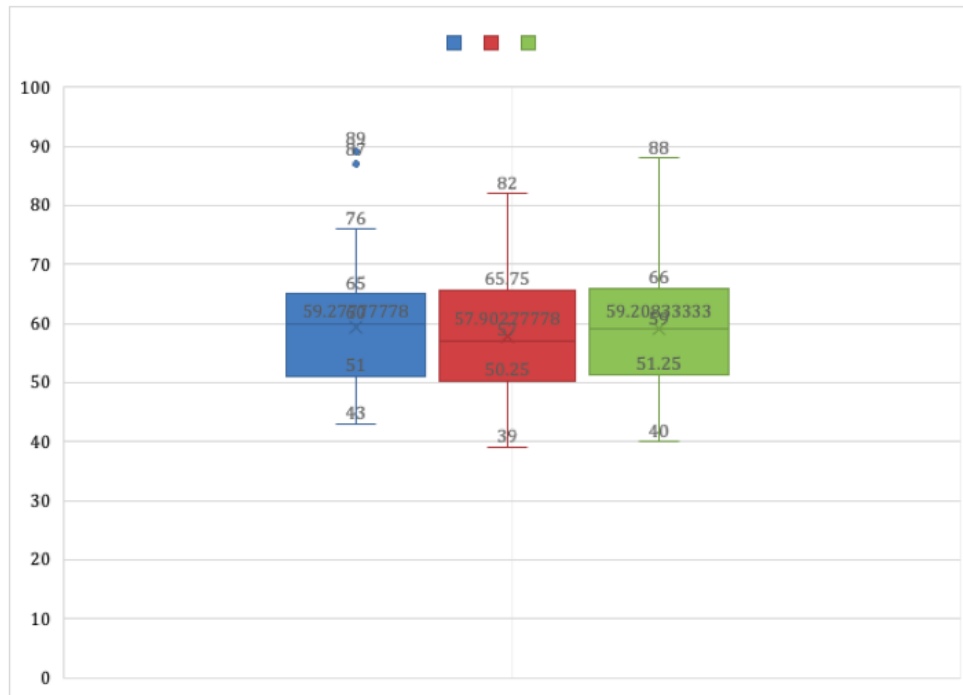
Figure 1: Distribution of Index Scores and Overall Score. BRI-MI-GEC

Figure 1 shows the values of BRI, MI and GEC in terms of their quartiles. In general, the three series have similar medians, with values between 57 and 65, indicating a comparable distribution. MI (red) has the lowest overall dispersion, with a range between 39 and 82. GEC (green) shows an interquartile range similar to that of BRI, but its lower limit reaches 40, and its maximum value is 88.

Another of the findings is that there are skills where 34% of students obtained scores considered significantly deficient in executive function, these were Initiate and Inhibit. They have difficulties in controlling impulses and inappropriate behaviors, as well as less developed ability to initiate tasks, followed by Plan/Organize and Working Memory with 31% and 30% respectively.

94% of the participants have developed the task monitor's ability to supervise tasks and identify errors.
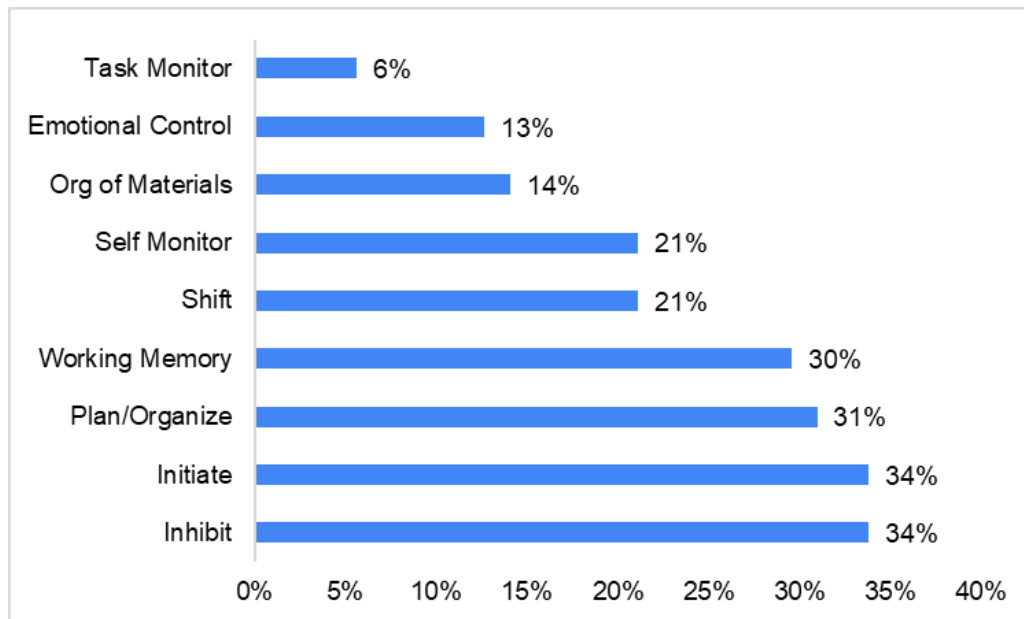
Figure 2: Frequency of Students With Compromised Executive Functions, Considered With Difficulties

Conclusions

According to the results obtained, students present a functional level in executive functions, which could be interpreted as a reflection of an adequate integration of the executive components, as proposed by Miyake's theory (2000). This model is used to explain individual differences in areas such as academic performance, emotion management and adaptation to new cognitive demands.

In the study conducted by Bylieva et. al (2021) they found that students have lower scores in the areas of goal setting and time management, which correspond to the Plan/organize scale where 30% of the participants present deficiencies.

Having this information at the beginning of the academic program provides an opportunity to create follow-up programs and favor the development of skills that have been identified as deficient. On the other hand, taking advantage of the normal level of functioning of the executive functions for the achievement of academic success. This study will continue with the application of an instrument that evaluates self-regulation strategies in educational contexts.

Acknowledgements

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