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PAPER

Influence of Self-Regulated Learning on the Academic Performance of Engineering Students in a Blended-Learning Environment

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ABSTRACT

The pandemic environment experienced for more than two years strongly accelerated the use of technological resources to support learning. Using these resources made it evident that higher education students expecting to succeed academically must master digital strategies. The combination of learning experiences and autonomous work required students to self-regulate their learning well to attain the expected performance levels for competitive work that characterizes the engineering profession. So, we designed an exploratory study to evaluate the effect of self-regulated learning on mechanical design students in a Blended Learning (BL) environment using Flipped Learning/Classroom didactics (FPC). Fifty-one students studying under two different educational-model curricula participated. The research employed a mixed methodology. For the quantitative part, the students' academic grades and results of the Motivation and Learning Strategies Questionnaire (MSLQ SF) applied in its short Spanish version were employed. A questionnaire for self-study management and a competency observation rubric based on the Marzano & Kendall New Taxonomy were used for the qualitative part. The results showed that the students with the best levels of self-regulated learning in BL and FPC contexts obtained the best results in cognitive, organizational, and motivational resource management strategies. They also improved their disciplinary skills and had a higher academic performance.

KEYWORDS

self-regulated learning, higher education, blended learning, competency-based education

1 INTRODUCTION

After spending more than 24 months immersed in accelerated, systematic use of information and communication technologies (ICT) caused by the school closures due to the COVID -19 contagion, we must indicate that we have entered a new stage in the development of learning environments. These have been adapted and transformed according to the training needs of the different educational levels [1, 2].

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Today, the blended learning modality has high acceptance, permitting a series of possible educational models to follow, characterized as flexible regarding space and time, synchronicity and asynchronicity, and using different applications and technology for the interaction and distribution of materials [3].

Blended Learning (BL) is a concept with many meanings, depending on whether referring to modes of delivery, technology, pedagogical models, instructional processes, behaviors, or some combination of them [4–6]. As stated in [7], the classic definition points to learning activities that combine face-to-face and non-face-to-face computer-mediated interaction. Based on the number of independent activities, there are three different types of impact: the first one refers to traditional or low-impact BL, where face-to-face instruction with the teacher predominates. The second one refers to BL with medium impact, where several of the learning tasks are replaced by online activities that re-quire more challenging technological resources. The third one, with high-impact BL, is firmly based on technological supports that combine remote and presential activities and require greater student autonomy for successful performance and learning [5, 8–10].

A deeper reading is presented on the potential of the flexibility of time and space, understanding that faculty and students have limited time in the classroom. For example, the flipped classroom and learning approach (FPC) can be carried out without much difficulty, as students access the learning materials and use classroom time to deepen the study of the subject with the teacher's support. FPC research has found that this methodology develops student autonomy and skills related to self-confidence and motivation [11]. Its difference is that BL works in two modalities that complement each other, while FPC inverts the traditional learning method by placing exercises before the lesson. Combined with other strategies, such as BL or gamification, it contributes to achieving more permanent learning and the development of critical thinking [12, 13]. Some other studies [14, 15] show a positive relationship between FPC and BL, favoring learning as well as the development of skills. This combination directly contributes to the students' satisfaction with their class work, which is essential to develop class engagement. Other conditions of the FPC that promote the SRL are as follows: student-centered approach, peer interaction, content and time well-organized digital environments, and active learning. All these conditions permit to improve the class time spent for solving doubts and consolidating knowledge [15, 16]

Learning experiences in the university classroom show that well-motivated students are more involved in their learning process, applying a high level of effort that results in better academic performance and greater personal satisfaction. As stated in [17], this perspective is a principle of primordial autonomy establishing that students make their own decisions, "becoming the true promoters of their learning" (p. 86). Authors of [18, 19] were among the first to point out the dimensions of motivation and self-sufficiency as the essential elements for achieving good performance in the classroom.

From a more traditional perspective [20–22], university students need a high intrinsic motivation because their work is usually very competitive, requiring greater self-regulation to achieve the best academic results. Therefore, student motivation is a condition to achieving self-regulation in the class, combined with a positive attitude and learning strategies [17]. As stated in [23], the conjunction of the motivational, affective, and cognitive dimensions is the main characteristic of the learning process.

Zimmerman's self-regulation model [24] is a widely known [25] and the most important precedent for the other SRL models. This model is based on a three-phase cyclical process: analysis, execution, and reflection. In the first phase of knowledge activation, students set their goals and strategies, while the motivational elements and expectations encourage them to achieve their goals. During the second phase of self-control, students execute and monitor their learning processes through concentration, self-learning strategies, self-monitoring, managing the study environment, and possibly searching for help. Finally, in the third self-assessment stage, the students evaluate their learning processes and performance, judge their effectiveness, and declare satisfaction with their work.

In fact, among the psycho-pedagogical studies of the last generations around the factors that affect the learning process, the one corresponding to self-regulation has gained importance since the 80s. The main contribution [26, 27] coincides in the identification of key phases for the study of self-regulation: planning/forecasting, monitoring/performance, and evaluation/reaction. From this range of contributions, researchers are inclined to the model of Pintrich [27] for the investigation of the subject, for its proven impact on formative processes [28], and for the successful dissemination of the model in instruments for measurement purposes. This model consists of four phases: planning, monitoring, control, reaction, and four areas of regulation: cognitive, motivational/affective, behavior, and context. One major contribution toward clarifying the SRL model is the Motivation and Learning Strategies Questionnaire (MLSQ). Its strength is to combine the cognitive and metacognitive scales with the motivation scale to obtain a more detailed information on the student's learning strategies [27].

One of the fundamental aspects of cognitive regulation has to do with the execution of strategies such as the proper management of anxiety, concentration, the ability to process information, and the student's perception of their efficacy [29]. Other actions are related to repetition, organization, time-and-effort management, peer learning, and help-seeking [23].

In an online learning environment, self-regulated learners are characterized by active participation and efficient control of learning experiences, ease in strategizing, monitoring of the thought process, help-seeking, positive motivation, independence from the technological platform through personal devices, and especially, adapting to Zimmerman's learning model [30]. Thus, the design and implementation of online programs promote good performance, self-management, and emotional commitment of the learner. Notwithstanding the preceding, students with low performance or particular motor, vision, attention, and self-management needs have difficulties with these technological tools [31].

Scientific and technological progress and the trends in professional training require preparing engineers with robust and up-to-date technical knowledge and social and personal skills that allow them to function successfully in the professional field [32, 33]. To address the problems and opportunities relevant in today's world, we must create study plans that migrate from the objective approach to one that is competency-based [34]. To meet this need and introduce the improvements required by the teaching-learning process, the Mexican university, where this study was carried out, regularly updates its study plans. In its latest adjustment, it incorporated competency-based curricular designs.

The Mechanical Design course aims to develop the necessary skills to analyze, select, design, and simulate different machine elements. Students of mechanical and mechatronics engineering are under the outgoing curriculum. In the current academic program, the subject is only taken by mechanical engineering students. In the semester of study, both curricula coexisted on this one occasion.

The BL environment consisted of a high impact type of face-to-face classes governed by the FPC sequence [35] and a web platform for online content activities. To leverage the classroom experience, students first carry out the thematic preparation with the educational resources encouraging e-Learning. Thus, the responsibility for achieving the basic knowledge of each subject falls on the student. The class's purpose is to resolve questions, conduct applied activities supervised by the teacher, and promote collaborative work, solving a mechanical design problem using specialized software. Subsequently, the student performs a closing summative assessment online and a metacognitive reflection on their learning to assess understanding and extend learning.

The educational platform is organized into modules corresponding to the thematic contents of the course. Each module begins with a section of activities with self-study material: essential readings, videos with examples, trigger questions for reflection on learning, and a self-diagnosis quiz which the students can take several times until they get a passing grade; the tool records the number of attempts to achieve a passing or better grade.

The following section contains detailed presentations of the topics, calculation tutorials with step-by-step instructions on video, industrial catalogs and additional material of interest from leading books or websites. The support resources section includes links to open-access calculation tools for specialized applications, such as MDSolids, Gear Generator, Solid Edge, SKF Belt Calculator, and widgets. Then comes the main activity, which consists of solving the module's topic for the semester project. The last section includes an interactive animation with a summary of the topics, a closing quiz with a summative evaluation, and an individual metacognitive reflection with questions that explore what was learned, how, what skills were acquired, their use, and how the learning was managed. The semester project involves selecting and designing power transmission components, for example, a bucket elevator. With each topic, the students elaborate part of their proposal and complete the entire design at the semester's end.

For this study, self-regulation can be understood as the process by which the students establish their learning goals. Besides, they can plan, adapt their cognition, and persist in the effort to achieve them from the regulation of intrinsic motivation [29]. Therefore, this work aimed to evaluate the effect of self-regulation on the learning of engineering students studying design in a BL environment. The research question was: How does self-regulation impact the academic performance of engineering students studying the subject of design in a predominantly online BL environment?

2 METHOD

A mixed-methods, sequential-exploratory methodology was used to support the results obtained in the quantitative stage to better understand their findings qualitatively and give depth to the analysis of self-regulation of learning in BL contexts [36].

2.1 Population and sampling

The study was carried out at a private Mexican university. The sampling was intentional and non-probabilistic, with the participation of 51 students from two Machine Element Design courses, each from two different academic programs: 13 were studying under the outgoing engineering program and 38 under the new engineering program. Of this sample, 73% were men and 22% women, 20 to 23 years old, with 21 being the highest value (54.3%). The students of the previous curriculum were in the 8th semester of their mechanical engineering or mechatronics degree, while those of the new plan were in the 6th semester of mechanical engineering.

2.2 Measures and instruments

Various instruments were used to collect self-regulation data. The quantitative tool consisted of an online questionnaire with the short version in Spanish of the Motivation and Learning Strategies Questionnaire (MSLQ SF). This instrument was initially designed to study motivation, achievement strategies, and performance [19]. Several reliability studies have been carried out on it in various cultural contexts since its appearance in 1988, some in Spanish [37, 38]. Later, an alternative version was proposed to improve reliability, reducing the questions to 40 (from the original 81) and changing the Likert scale from 7 levels to 5; they called the new instrument MSLQ SF [39]. This version has been validated in Spanish [40], structuring a Motivation scale with two factors and a Learning Strategies scale with seven, with a Cronbach's alpha of 0.848 and a KMO sample adequacy of 0.907. More recently, [41] proposed a review, arriving at a version with 41 items, later consolidated to 37, with a Cronbach's alpha of 0.883 and a KMO test of 0.89, concluding that this version is valid and reliable for its application. This instrument is organized into two large scales: Learning Strategies (with six factors) and Motivation (with two factors). Its five-level Likert scale ranged from 1 ("not very successful") to 5 ("very successful"). This version was used in the present investigation. To assess academic performance, we used the students' grade history from the previous four semesters to the implementation as another quantitative indicator.

Two other instruments were also used for qualitative analysis: (a) A 17-item questionnaire to explore self-study management (SSM) with closed and open questions that explore personal study strategies, the value of effort, and the sense of achievement. (b) The Competere tool, which is an original competency observation rubric [42], has a version applicable to the machine element design course and was previously tested [43]. It consists of four performance levels based on the Marzano and Kendall taxonomy [44] to assess five competencies: three of mechanical design and two of engineering training.

This study had a couple of significant limitations regarding the instruments and their measurements. First, the population of students taking the mechanical design course was small: 51 people. With a confidence level of 95% and a margin of error in the responses of 5%, the sample size requires the participation of 46 students, precisely the number of students completing the MSLQ SF and SSM questionnaires. The observation rubric and the grade history could be applied to the entire population. Secondly, it must be considered that although experts reviewed the Spanish versions considering translation and educational psychology to obtain clear, relevant, and neutral wordings, there is always the possibility of students' difficulties in reading comprehension that could affect the psychometric properties of the instrument.

2.3 Data collection and analysis

An online respondent tool was used to collect data from the MSLQ SF and SSM questionnaires, which first displayed the institutional privacy and informed consent notice. Participation was voluntary and only after pressing the legal authorization button to start. The exercise took 15 minutes to complete. It was carried out during the last week of classes of each course. The evaluation dimensions of the MSLQ SF questionnaire are: For the Learning Strategies scale: elaboration (5 items), organization (7 items), metacognitive self-regulation (7 items), intrinsic goals (4 items), administration (2 items), and effort self-regulation (6 items). For the Motivation scale: anxiety (4 items) and task appraisal (2 items). The data was reviewed using descriptive statistics, with the support of Excel and SPSS, version 27.

The evaluation dimensions of the SSM questionnaire are self-study strategies (7 items), determination (3 items), engagement (2 items), study environment (1 item), and appreciation of effort (4 items).

The Competere instrument allows assessing the development of three disciplinary design skills and two transversal skills. The first ones consider knowing and applying design methodologies, carrying out component detail design, and detecting strengths/weaknesses to optimize proposals. The second includes the use of specialized software for design and reporting and explaining the meaning and purposes of the engineering profession. These competencies are rated with four levels of progressive cognitive domain: Retrieval, Comprehension, Analysis, and Use of knowledge, or Not Observed if no evidence is found.

The results of academic achievement included the historical data of four previous semesters, all corresponding to the previous curriculum, and the current semester data, which included both curricula, in terms of the grades obtained in the areas in which the course is regularly graded: classwork, evaluations, the design problem, and final average.

3 RESULTS

3.1 MSLQ SF

In this application, the MSLQ SF instrument showed acceptable reliability and sampling adequacy indices, with a Cronbach's alpha of 0.863 and a KMO test of 0.734. Although this last value is medium, it is enough to assume that the variables properly correlate with each other to validate the sampling adequacy.

Figure 1 shows the mean values for the MSLQ SF for the previous (P) and current (C) curricula by the following factors: elaboration (EL), organization (OR), metacognitive-behavioral self-regulation (MCS), goals (GO), time and resources management (TRM), effort in self-regulation (ESR), anxiety (AN), and task appraisement (VA).

The factorial analysis results show better levels of self-regulatory management for the students of the new curriculum than for those of the previous one in Learning Strategies, but this does not occur in the factors of the motivational dimension. The mean and similar values in the OR factor speak of the work it takes for both groups to systematize their notes and study sessions. The AN and VA factors do not present visible differences between the results of the two groups of students, both being quite effective for stress management but less so in the assessment of study tasks. In both groups, it can be seen that they are more successful in planning their strategies than in organizing themselves to carry them out. Both manage their resources better than their effort, know how to manage their anxiety, and value the task to be performed to a lesser extent. Their motivation and resolution are medium to high, they greatly appreciate the effort made and the creation of their study environments ranges from fair to good.

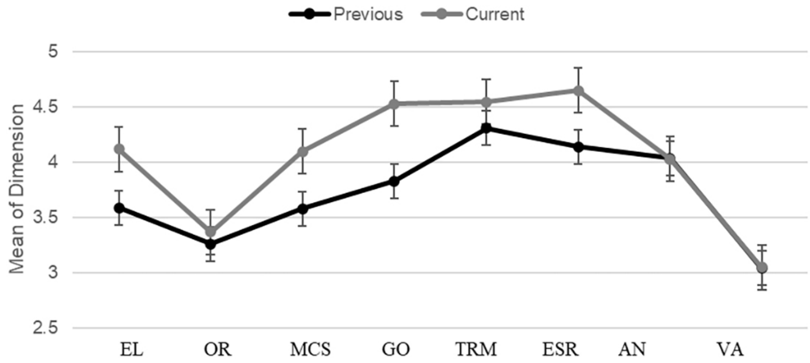

Fig. 1. MSLQ SF: Mean scores by factor for the previous and current curricula. Likert scale where 1 is equivalent to "not very successful" and 5 is equivalent to "very successful"

The distribution of frequencies of self-regulation is presented in Figure 2. It confirms that the students of the incoming curriculum (current) achieved more. Still, the decomposition in the different levels reveals that there are also students with high self-regulation in the outgoing group (previous), but proportionally they are less, both within their group and compared with the other. In both groups, a better level is perceived in self-regulation of effort (b) than in metacognitive-behavioral (a).

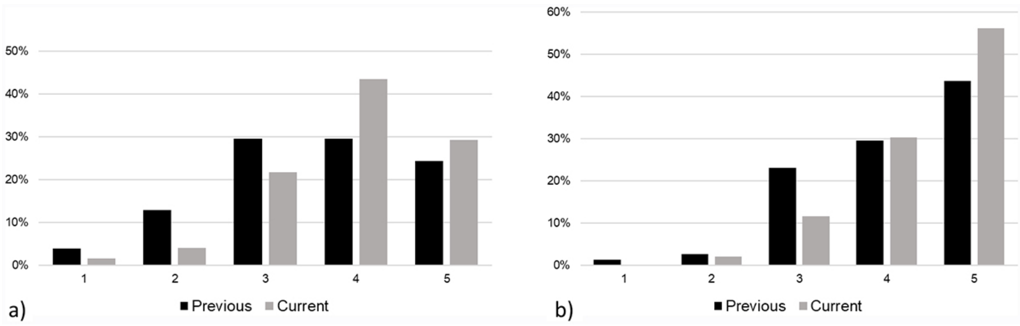

Fig. 2. Self-regulation frequency distribution: a) MCS, and b) ESR. Likert scale where 1 is equivalent to "not very successful" and 5 is equivalent to "very successful"

3.2 SSM

Table 1 shows the distribution of responses for the items that make up the dimensions of this instrument. It can be seen that the incoming curriculum presents better levels of performance in handling most of the factors but not all of them. This group of students has better management of their learning strategies, shows higher resolve to study, and has good general motivation. For organizing information and setting measurable goals, the outgoing curriculum is more effective. The same is true for creating a study environment or place; in appreciation, they have done hard work and taken full advantage of online learning resources. They have a greater need to consult the teacher in self-study tasks, and it is more difficult for them to concentrate.

As for successful autonomous learning, 60% of students in the incoming curriculum perceived they achieved it, and 27% believed they partially achieved it. Regarding students in the outgoing plan, 46% felt that they did not achieve it, and 23% perceived that they partially achieved it. The results can be seen in more detail in Figure 3, which presents the distribution of responses to this question. This last result is very significant concerning the appreciation each curriculum group has for their independent learning work and the self-regulation required. Success in self-regulation occurs when the student positively perceives their ability to carry out a particular task. Organizing for self-study had medium levels of success in both groups, and the difference between the two was not very large; this indicates difficulties in planning their tasks, even if the goals are clear. The engagement with the class, higher in the new group of students, seems to make a significant difference in implementing strategies to achieve better learning management and self-regulation.

Table 1. Distribution of SSM answers for "successful" and "very successful" in a five-level Likert scale ranged from 1 ("not very successful") to 5 ("very successful")

	Previous [%]	Current [%]
Strategies	51.5	56.2
Resolution	38.4	69.6
Motivation	57.6	74.2
Ambiance	76.9	72.7
Appreciation	79.5	67.6

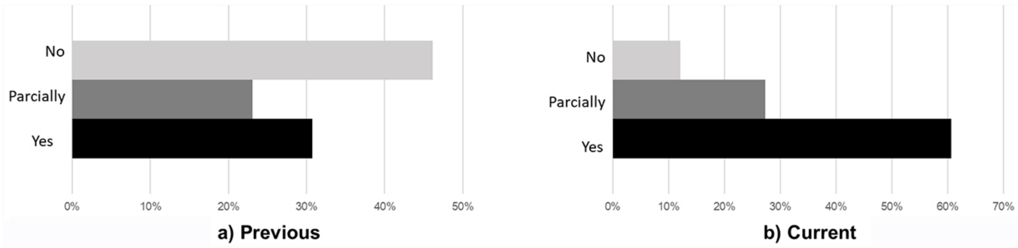

Fig. 3. Distribution of answers to the question "Do you consider that you achieved a good self-regulation of your learning?" for previous and current curricula

3.3 Performance assessment

Table 2 summarizes the final evaluation of disciplinary and transversal competencies for engineering design [45]. The numerical values correspond to the levels of the Marzano and Kendall scale converted to the following designations names that facilitated the evaluation: 0 = Not observed, 1 = Incipient (Retrieval), 2 = Basic (Comprehension), 3 = Solid (Analysis), and 4 = Outstanding (Utilization). They represent the model values for each group, which appear most often in each assessment.

Table 2. Performance assessment for both curricula

Competency	Expected Value	Previous	Current
		Measured Value	Measured Value
1-1 Applies design methodologies	4	2	4
1-2 Makes a design in detail	4	3	4
1-3 Evaluates the strengths & weaknesses of the proposal	4	2	3
2-1 Uses specialized software	3	3	3
3-1 Explains the meaning and goals of his profession	3	3	0

Regarding the disciplinary design competencies 1-1 and 1-2 achieved at the end of the semester, it is observed that most of the current curriculum performed better than the previous curriculum. Most of the former achieved the expected aptitude for handling design methodologies and detailed design work, which speaks well of their ability to create new engineering solutions. In the solution-optimization competency 1-3, most new-generation students confirmed their ability to analyze solutions but did not attain the Outstanding value as a group. The previous-generation students have more dispersion in their responses, with their model value at the Basic level.

Both groups achieved satisfactory levels for the 2-1 specialized software management competency. Regarding the 3-1 competency for understanding the meaning and goals of the engineering profession, the current students had little interest in this part of their training, contrasting sharply with the higher values of the previous curriculum.

3.4 Academic achievement

Table 3 summarizes the academic achievement results (grade history) for the implementation semester and the previous four. From the August–December 2019 semester to the February–June 2021 semester, the course had to be taught online due to the pandemic, using the institutional LMS platform and classes through a videoconference service for virtual meetings. In the August–December 2021 semester, classes returned to face-to-face. The February–June 2022 semester was taught with the BL resources for the self-regulation of learning. That semester marked the previous-curriculum students taking the mechanical design course for the last time as the students of the new curriculum took it for the first time.

The evaluation of the course may have some variants, depending on the period and some internal activities of the institution involved in determining the final course grades, but, on average, the global grade can be integrated with 55–60% of the class work, 20–25% for evaluations, 20% for the design project, and 5% for other activities. The class work comprises the exercises carried out in class and the homework; the evaluations comprise some quizzes, partial evaluations, and the final exam. The design project is a problem that is solved throughout the semester.

Table 3. Academic achievement of the implementation semester and the previous four

Semester	2022-FJ		2021-AD (Δ)	2021-FJ (+)	2020-FJ (+)	2019-AD (+)
	(*)	(Δ)				
Curricula	*Current*	*Previous*	*Previous*	*Previous*	*Previous*	*Previous*
Classwork	93.51	87.78	81.20	82.90	80.78	84.25
Evaluations	94.70	61.88	57.94	76.93	80.36	67.16
Design problem	95.40	90.00	89.13	88.70	(++)	(++)
Final average	94.71	83.04	78.13	82.86	81.96	81.75

Notes: FJ = February–June, AD = August–December; (*) Semester taught with BL & FPC resources for self-regulated learning; (Δ) Semester taught face-to-face; (+) Semester taught online without self-regulated learning resources; (++) Semester under pandemic conditions; the activity was not evaluated.

4 DISCUSSION

The objective of this study was to assess the effect of self-regulation on learning engineering design in a BL environment. As stated in [29, 46], information technologies enrich engineering education programs by providing learning environments that stimulate knowledge, practice, adaptability, and self-regulation. Therefore, it was expected that the BL environment would support students in their work of learning mechanical design in an efficient and self-regulated manner.

From the results using all these resources, it was possible to infer some of them were more successful than others. Among those liked the least, especially in the beginning, were the thematic readings, the support videos, and the diagnostic evaluations. Among the comments about these, the students first considered them a waste of time, but then they valued these resources when they discovered that they needed this knowledge to work in class, complete the project, and better organize their self-study time.

The video tutorials with the design methodologies, the calculation or simulation software, and the interactive thematic summaries were the most used for learning the different topics. These elements allowed the students to review the contents and methods as often as necessary to master the design process beyond the classroom without constantly consulting the teacher. This gradually generated a learning culture where the teacher was no longer the primary source of information (the platform was). Instead, the teacher became the facilitator who provided relevant elements to make distinctions, resolve questions or conflicts in the design, explain the software, and assess students' performance. In particular, the calculation widgets and interactive summaries allowed students to test their knowledge and extend their learning to the semester project activities, an application in which they performed well from the beginning, thereby gaining interest and self-confidence. This positive relationship among BL resources, the FPC strategy, student engagement, and good performance are consistent with what has been reported in other studies [14, 46, 47].

Figure 1 shows that although the two groups of students used the same BL resources and FPC methodology, their responses differed for most of the dimensions analyzed. The current generation performed better than the previous one. However, three dimensions were exceptions: anxiety management (AN), task assessment (VA), and organization (OR), where there were no significant differences between the results of the two groups of students. The AN & VA dimensions comprise the Motivation factor, implying that there were no appreciable differences in this construct between the two groups, with one being successful in managing stress but less in assessing the importance of learning tasks and how they are organized to carry it out; this does not provide a distinction to differentiate levels of self-regulation. Both groups were more successful in planning their strategies than organizing themselves to execute them; they managed their resources better than their efforts; they knew how to manage their anxiety; they valued the task to be carried out to a lesser extent; their motivation and resolution were medium to high; they greatly appreciated the effort made, and the creation of their study environments ranged from fair to good, what is consistent with [48].

The results of the SSM questionnaire (Table 1 and Figure 3) confirmed that students in the current curriculum had better achievement. Still, the breakdown into the different levels reveals that the previous-curriculum group also had students with high self-regulation levels, although they were proportionally less, both within their group and compared with the other. Both curricula perceived better self-regulation of effort than cognitive. The differences between the levels of self-regulation show that each generational group is distinguished by how they approach their study strategies, manage their learning, engage, and assess the given task. Generally, this management is more successful in the incoming generation than the outgoing one.

This may be because the new students are younger, just starting the second half of their study plan, were required to have a higher-grade point average and SAT score for their university entrance, and because being the first generation of a new curriculum naturally brings a good level of personal determination, appreciable in the values for the Resolution and Motivation dimensions (see Table 1). Attachment to the class (extrinsic motivation) is the motivational dimension that seems to have made a difference in implementing strategies to achieve better learning management and self-regulation.

Table 1 and Figure 3 show that the previous-curriculum students perceive they make a much greater effort to learn on their own and also feel a greater need to consult the teacher, although both groups recognize that having self-study topics improves their skills to learn. Organizing for self-study was medium in both groups, and the difference between the two was not significant, indicating their difficulties in planning tasks, even though the goals were clear. Regarding successful autonomous learning, the current generation considered that they did succeed, while the previous generation perceived that they did not achieve it or felt they had partially achieved it. This last result is very significant considering each generational group's appreciation for their work of independent learning and self-regulation; successful self-regulation occurs when the student positively perceives their ability to carry out a given task [17–19, 24].

The assessment of competencies (Table 2) and academic performance (Table 3) reveal an essential difference in using BL resources and their effect on design learning. In general, the students of the new generation showed a better development of disciplinary design skills than the students of the outgoing curriculum. This is consistent with the results of motivation and self-regulation reported in the previous paragraphs, in the sense that both factors are practical means to facilitate learning and achieve academic success, agreeing with the findings of other works [14, 15, 49]. Both generational groups achieved the expected digital competency performance in using specialized software for information management and calculating and simulating mechanical components. The fact that there was no difference in development between the curricula, as in the other cases, may be due (as indicated in [50, 51]) to the fact that most of the current university students were born in this century and have a very high level of digital literacy and usage, especially with communication and collaboration tools. Although there is a gap between the communication and academic contexts, the training that these students bring in the constant discovery of new software allows them to learn what is relevant to their academic work quickly and with interest. Finally, concerning the competency that refers to the social dimension of the engineering profession, it is noteworthy that the outgoing generation regards this highly, but the incoming generation hardly does at all. This may be because the students of the generation about to graduate already have work experience in their professional field, which allows them to identify the role of engineering and their responsibilities more clearly within the industrial world. The students of the current generation are younger, in the middle of their training and they see engineering as a "study" field not as one of work, and still do not have work experience, so they ignore the role of engineering societies of graduates in the business world and society.

The results of academic performance in Table 3 show that the new version of the website with the BL & FPC autonomous learning resources helped to achieve better learning, reflected in higher grades. The implementation semester shows better grades by type of academic activity and in the final grade for the course than the periods in which the resources were not used. Also, it is observed that the students of current generation who take this course for the first time show a high level of academic achievement, with grades above 90/100. On the other hand, the members of the previous generation had lower achievement (grades) than the current generation but a little better than preceding previous generations.

The student's independent work based on the BL environment proved to favorably support self-regulated learning behaviors, especially those that have to do with effort and management of time and resources. In the same way, a favorable correspondence between the FPC approach and the BL environment could be appreciated as a positive combination to improve the student's academic performance and to stimulate their engagement with the class topics. These results allow us to confirm that digital teaching resources, introduced in a good and accessible configuration for the student, could help to create a student culture of motivated and regulated self-learning, which fosters better academic achievement. This is consistent with other studies reported in the literature in the last years [17–19, 24, 52, 53].

5 CONCLUSIONS

With the findings of this work, it could be verified that the students with the best academic performance in the Design course were the ones who best leveraged their class experience and aligned it firmly with BL & FPC elements [47]. They effectively managed their cognitive, organizational, and motivational resources, resulting in better self-regulation. The hook toward class engagement was the motivational dimension that seemed to make a difference in implementing strategies to achieve better levels of learning management and academic performance. This implies that online autonomous learning resources are effective to the extent that students feel motivated and have the necessary strategic and management skills to take advantage of them.

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