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Review

Learning Models for Higher Education in Engineering: Motivation, Self-Determination, and the Role of Information and Communication Technologies

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Abstract: In the last decade, great strides have been made to increase access to education and enrollment rates at all levels (primary, secondary, and higher education). Actions such as promoting equal access to education, preventing school dropout, and establishing free education, among other actions proposed by organizations such as UNESCO, seek to guarantee the universality of education. This is undoubtedly a great challenge, and to address it, it is necessary to characterize how students face the learning process, considering factors such as autonomy, competencies, and their own basic psychological needs, looking for effective learning models based on students' needs in a changing world, where ICTs play a relevant role. This research analyzes learning models, motivation, self-determination, and technologies used for learning achievement in higher engineering education. The study will highlight relevant initiatives and the most commonly used technological tools. It will also identify learning models that seek to link emotional intelligence, self-determination, cognitive skills, and ICT. The PRISMA protocol guided the study, finding 132 relevant articles to be analyzed and proposing best practices in using learning models, strategies, and ICT to foster students' intrinsic motivation.

Keywords: engineering; higher education; motivation models; self-determination; emotional intelligence; metacognition; technologies; ICT

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1. Introduction

Motivation, self-determination, and technologies are important in higher education. For this reason, various studies specifically aim to understand human behavior in this learning-centered field.

In higher education, it is not easy for students to achieve motivated learning at all stages of their vocational training, and, unfortunately, many drop out. Motivation refers to behaviors' energy, direction, persistence, and purpose, including intentions and resulting actions [1]. As shown in Figure 1, motivation can be classified as intrinsic and extrinsic motivation; the difference between intrinsic and extrinsic motivation lies in the location of the force that motivates the individual to perform certain behaviors. In intrinsic motivation, the force is due to internal factors (needs, interests, curiosity, satisfaction, and enjoyment). In other words, the performance of the activity produces satisfaction. In contrast, extrinsic motivation is due to external factors (social pressure, reward, and punishment). In this case, the motivated behavior is performed to achieve something ("rewards") and not for the enjoyment of performing the behavior itself [2].

Figure 1. Summary of motivation, source: own elaboration.

Motivation and self-determination are strongly linked. The self-determination theory explains human personality and motivation based on the assumption that intrinsic behaviors make psychological well-being possible when the basic psychological needs of autonomy, competence, and social interaction are fulfilled [3].

Self-Determination Theory (SDT) represents a macro theory that addresses human motivation and personality, focusing on the fundamental concerns of growth and the innate psychological needs of individuals. This theory focuses on the level of self-motivation and self-determination in individual behavior [4–6]. SDT comprises six mini-theories, which complement each other and are based on basic psychological needs to form the macro-theory of self-determination: cognitive valuation theory, organismic integration theory, causality orientation theory, basic psychological needs theory, goal content theory, and relational motivation theory [7]. SDT identifies three innate needs that, if met, allow for optimal functioning and growth: Competence, Relatedness, and Autonomy [8].

However, the self-determination theory is intertwined with other theories (see Figure 2), such as metacognition and emotional intelligence. Suppose we add that each person in a training process has or could have certain technologies that favor their learning. In that case, it is challenging to recognize which could be effectively and sustainably applied to education.

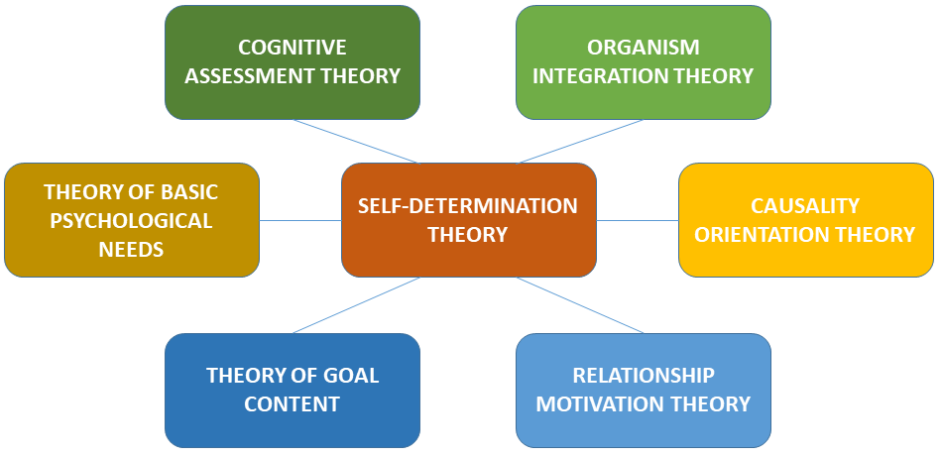

Figure 2. Self-determination theory and the six theories that compose it.

In higher education and focusing on engineering education, the interplay between these theories is very relevant. Identifying the patterns and factors that motivate learners is crucial for tutors and learning analysts to understand motivation better to adapt their practices to promote effective, autonomous, and motivated learning among learners [9].

As a complement, in today's digital world, information technologies play a crucial role in education, with innovative environments and digital experiences to increase motivation, improve learning, and enable more students to achieve learning through emotional intelligence and psychological well-being. From a technology perspective, there are recurrent tools mentioned by experts that support the learning [10], gamification alongside serious games [11], visual programming languages [12], cybersecurity [13], virtual laboratories [14], and digital environments [15], among others.

Everything explained above seeks that students learn effectively, autonomously, and with high motivation. However, it is known that many of these factors fail, and what is achieved in some cases are high levels of failure and dropout from higher education. To address these problems, learning models have been developed; these models correspond to a system based on methodologies composed of characteristics, strategies, and guidelines designed to guide the learning process; with them, we seek to respond to a historical need for teaching: how to promote learning, motivational factors and personal characteristics of each student. The learning model is related to other factors that contribute to learning between students and teachers and, in turn, understands the relationship between emotion and learning [16].

On the other hand, it is known that activating prior knowledge and accessing it is fundamental to the emotional component. For example, the constructivist approach considers several elements linked to the limbic brain because this approach points out that prior knowledge must be activated to build new knowledge: starting prior knowledge involves emotion, language, and memory [17]. The concept of academic emotion was first proposed by Pekrun, which is defined in terms of achievement activities or achievement outcomes. Over recent decades, varied research has been generated to examine the relationship between emotions and learning achievement in various learning environments, to discover how emotions arise and are regulated, what precedes them, and how they relate to behavioral, motivational, and achievement outcome achievement [16].

Finally, the role of ICTs is fundamental since the implementation of technologies in education should always be aimed at helping students to experience an improvement in their learning process. As the 2017 Horizon Report explains, this document guides educational institutions by identifying emerging trends and challenges in higher education in the coming years. The document subdivides the directions to be met in the short, medium, and long terms to carry out its realization [18].

This research aims to identify relevant literature and discuss learning models, motivation, self-determination, and technologies used for learning achievement in the context of higher education in engineering. The study highlights technological initiatives and tools used to enhance, improve, innovate, and motivate students in higher education, especially in engineering. It also seeks to relate emotions, emotional intelligence, self-regulation, and cognitive and social skills. We provide an outline summarizing this data over the last five years, organized according to each theme.

For this purpose, a Systematic Mapping Study (SMS) was carried out, following the PRISMA guide [19] and adapting the protocol of Petersen et al. [20]. Systematic mapping is a particular type of literature review; it is a secondary type of study used to identify, evaluate and synthesize research, mainly of a primary nature; although it does not exclude other types of publications, its purpose is to answer questions previously posed to guide the review [21]. As a result, a set of 132 articles studying student motivation from the perspective of self-determination theory, metacognition, emotional intelligence, and ICT was selected.

This report includes several sections. Section 2 covers the essential concepts related to the research in general. Section 3 details the methodology and results of the article

selection process. Section 4 then discusses the study's main findings. Section 5 discusses the main challenges of the theories presented and their application in engineering higher education. The study's limitations are explained in Section 6. Finally, Section 7 presents the conclusions, implications, and possible future research.

2. Theoretical Background

2.1. Metacognition

Metacognition is the ability to self-regulate learning processes. It involves a set of intellectual operations associated with the knowledge, control, and regulation of the cognitive mechanisms involved in a person's gathering, evaluating, and producing information [22].

In learning, metacognition refers to a person's ability to reflect on and become aware of one's thinking and learning processes. It is the ability to think about how one is learning, monitor progress, evaluate one's level of understanding, and regulate the strategies used to achieve learning objectives [23].

By developing metacognitive skills, students can plan their studies, set clear learning goals, select the most appropriate strategies to approach a task, monitor their progress, and evaluate their performance. It also enables them to identify obstacles or difficulties in their learning and apply self-regulation strategies, such as adjusting their approach or seeking help when necessary [24]. Just as metacognition plays a crucial role in learning, so does emotional intelligence, described below.

2.2. Emotional Intelligence

Emotional intelligence is the set of psychological abilities of human beings to understand, express and manage their own emotions and to recognize and understand those of others. In this sense, emotional intelligence also allows people to make conscious use of all this information in terms of emotions to guide their way of acting, thinking, and relating to others. As such, the concept of emotional intelligence includes from personal to interpersonal feelings, that is, both those associated with the private sphere and self-knowledge, as well as those related to the social dimension and the ability to understand and develop empathy with the emotions of others [25]. Linked to emotional intelligence are also the executive functions focusing on emotion regulation.

2.3. Executive Functions

Executive functions are high-level cognitive skills that allow us to plan, organize, regulate our behavior, maintain focus, and switch tasks, among other things. They include skills such as working memory, cognitive flexibility, inhibition of automatic responses, and emotional self-regulation. Executive functions are fundamental to critical thinking, decision-making, and academic and occupational success [26].

2.4. Information and Communication Technologies (ICT)

ICTs are technologies developed today for more efficient information and communication, which have changed how we access knowledge and human relations. ICT is the abbreviation for Information and Communication Technologies. Information refers in this context to the transfer of data in an innovative way, including text, images, and audio.

Communication refers to the tools that enable the message sent by the sender to be correctly decoded by the receiver—for example, user information platforms.

ICTs permeate all fields of human knowledge and social life: home, education, entertainment, and work. They transform the mental processes of knowledge acquisition [27].

3. Materials and Methods

Petersen's proposal for the systematic mapping study (SMS) [20] provides an approach to systematically verify, analyze and classify results related to a specific topic or area of interest. This technique facilitates the scoping of research and the categorization of knowledge gained.

Conducting a SMS implies following or modifying the steps described in Figure 3 sequentially, adapted from [28]. Thus, as the different stages of the process are completed, concrete results have been obtained that form the direct input for the next stage to achieve as a final result a systematic mapping.

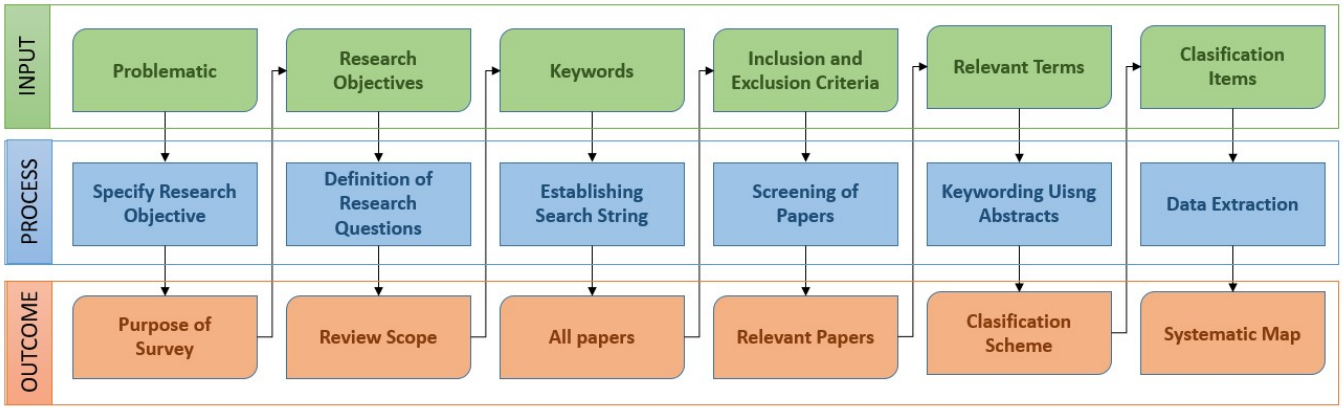

Figure 3. Stages of the systematic mapping process, adapted from [28].

The activities that make up the systematic mapping process are described in the following sections.

3.1. Goal and Research Questions

This SMS aims to analyze and categorize the strategies employed in the last five years to reduce school dropout and increase student motivation. These initiatives will be approached from the perspective of self-determination theory, metacognition, emotional intelligence, and the incorporation of information and communication technologies (ICT).

In this SMS, the procedure started with elaborating research questions, which form the central foundation of the mapping by providing an overview of the specific area [20]. Table 1 presents all questions and their rationale. These questions facilitated the selection, analysis, and classification of information in the study area.

Table 1. Research Questions.

Question	Objective
RQ1: Of the selected papers, how many propose initiatives related to improving the learning motivation of higher education students in engineering?	Recognize and identify documents proposing initiatives to improve student motivation to answer the following questions.
RQ2: For related papers, how many address innovative techniques about self-determination and/or emotional intelligence?	Recognize if the techniques regarding self-determination and/or emotional intelligence are essential.
RQ3: How have the related proposals or initiatives evolved over the years? Do they improve learning and decrease attrition?	Analyze the proposals and initiatives to evaluate whether their use over time favors student retention and learning.
RQ4: What technologies are being used, and what would be their most recurrent applications? Are they effective?	It allows us to recognize the technologies' impact using different techniques.

3.2. Data Sources and Key Words

The following databases were systematically searched to obtain the best literature coverage of the research topic: WoS, Scopus, IEEE, ScienceDirect, and ACM. The analysis included studies published over approximately five years (from 2018 to the present). A combination of keywords related to "engineering", "higher education", "technologies",

"ICT", "ICTS", "motivational models", "self-determination", "emotional intelligence", and "metacognition" were used.

3.3. Search String

To generate a search string, we identified the keywords from the research questions and the objectives and then linked them with logical connectors. This search string was applied in the search engines and validated by the researchers. The resulting string with AND/OR logical operators was:

("engineering" AND "higher education" AND (technologies OR "ict" OR "icts") AND ("motivation models" OR "self-determination" OR "emotional intelligence" OR "metacognition")).

3.4. Data Extraction

The search and data extraction process involved the inclusion of databases and websites with access to digital libraries. These platforms would encompass search engines capable of conducting searches using specific search strings to retrieve numerous relevant papers. The chosen data sources comprised WoS, Scopus, IEEE, ScienceDirect, and ACM.

3.5. Inclusion and Exclusion Criteria

The studies found through the academic search engines mentioned earlier were selected based on the following inclusion/exclusion criteria:

Inclusion Criteria:

- Published papers in English from journals and conferences.
- Full papers related to the research.
- Papers from the last five years were included.

Exclusion Criteria:

- Technical reports, abstracts, editors' comments, state of the art.
- Studies before 2018.
- Studies without an author.
- Documents that do not reflect higher education environments
- Duplicate studies in different databases
- Documents that do not come from traceable journals or procedures.

3.6. Search Execution

The search string was applied to the selected sources, and an initial quantity of 471 jobs was obtained (see Table 2). The information was extracted using the export tools of each of the digital libraries. After eliminating those doubly indexed jobs, it was reduced to 444 jobs.

Table 2. Sources for the automated search.

Electronic Data Source	URL	Resource
Web of Sciences	https://www.webofknowledge.com (accessed on 29 June 2023)	31
SCOPUS	https://www.scopus.com (accessed on 29 June 2023)	22
IEEE	https://ieeexplore.ieee.org/Xplore/home.jsp (accessed on 29 June 2023)	8
Science Direct	https://www.sciencedirect.com (accessed on 29 June 2023)	408
ACM	https://www.acm.org/ (accessed on 29 June 2023)	2

Next, the inclusion/exclusion criterion was applied by reading the titles, resulting in 165 papers. Finally, these papers were read according to the abstract, resulting in 132 pieces (see summary in Figure 4). The list of articles found can be found in Appendix A, Table A1.

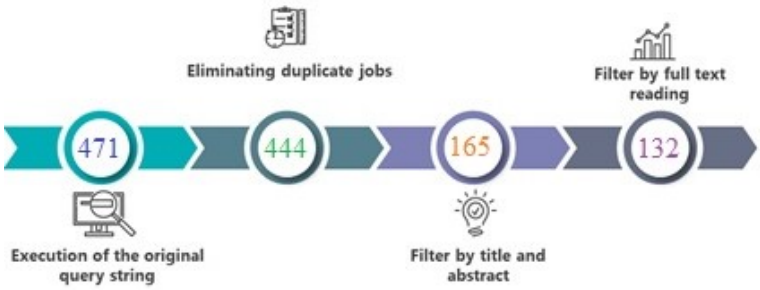

Figure 4. Consolidation of selected publications.

3.7. Classification Scheme

Publications are classified into three dimensions: temporal, type of database, and content (keywords). The temporal dimension ranks the papers according to the year of publication, considering the last five years, the period 2018–2023.

The database type dimension refers to the origin/source of the publication. The size in terms of the content of the magazine itself is classified into engineering, higher education, technologies/ict/acts, motivation, models, self-determination, emotional intelligence, and metacognition.

The proposal type both proposes analysis-oriented solutions but with a technological component. The dimension classifies jobs into the following:

- Analytical: Works that carry out analyses, comparisons, or literature reviews concerning the research topic.
- Practical: They use studies or work related to technological tools to improve learning.
- Both: Propose analysis-oriented solutions but with a technological component.

3.8. Map Construction

The final product of the systematic mapping phase was a map to facilitate representation and analysis. Figure 5 shows the papers classified according to the type of database and keywords and, on the right side of the figure, shows the classification of publications by year range. It should be noted that this map only includes those articles that consider, within their analysis or proposals, any of the dimensions individually. Those articles that consider integrating two or more dimensions studied are reflected in Table 3.

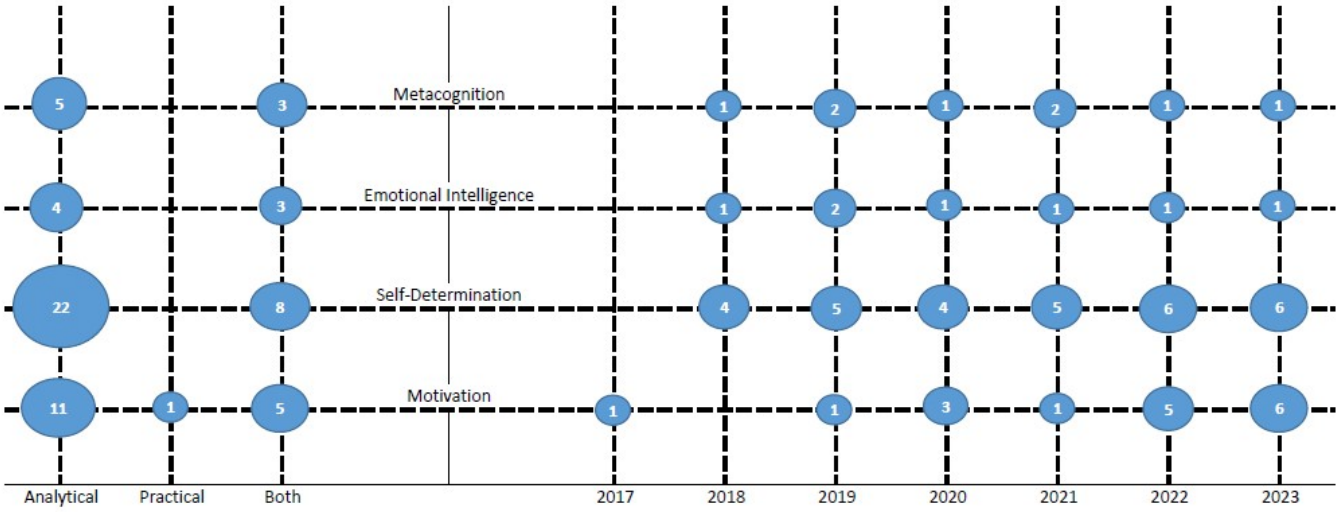

Figure 5. Representation of the systematic mapping.

As seen in Figure 5, most papers are analytical within motivation and self-determination studies. Fewer studies provide a practical component to their studies. It is interesting to

note that there is only one study that only considers practical work. Furthermore, the distribution of papers per year has been consistent from 2021 onwards, which coincides with the COVID-19 pandemic period. To date, in 2023, almost the same amount of work has already been registered as in 2022.

Beyond these figures, it is necessary to go deeper into the analysis of those papers that consider more than one category, such as Motivation and Self-determination or Metacognition and Motivation. In Table 3, we show some cases of studies where more than one category is covered.

Table 3. Number of papers considering more than one category.

Cases	Motivation	Self-Determination	Emotional Intelligence	Metacognition	Total
Case 1	✓	✓	-	-	5
Case 2	✓	-	✓	-	2
Case 3	✓	-	-	✓	0
Case 4	-	✓	✓	-	2
Case 5	-	✓	-	✓	3
Case 6	-	-	✓	✓	1
Case 7	✓	✓	✓	-	1
Case 8	-	✓	✓	✓	2
Case 8	✓	-	✓	✓	0
Case 9	✓	✓	-	✓	1
Case 10	✓	✓	✓	✓	5

Checkmark indicates that the category is considered in the corresponding scenario.

As can be seen, a few papers consider more than one category in their studies. This situation implies that only a few proposals develop comprehensive studies of the effects of combining categories and the relationships between them.

4. Results

This section presents the findings from our analysis of 132 papers on learning models, motivation, self-determination, and technologies in higher engineering education. We analyzed critical aspects, including engineering, higher education, motivation models, self-determination, emotional intelligence, metacognition, technologies, and ICT. The results have been ordered according to the sequence in which the answers to the research questions are sought. Figure 4 shows the number of papers contributing to the research resulting from the filtering process. Of the total number of articles selected and according to the type of study of the publications, they could be classified into Analytical, Analytical and Practical, and Practical, the percentage of the total being the following value, respectively: 96 publications 73%, 33 publications 25%, and 3 publications 2%. Of the total, analyzed according to the topics addressed in this study, the following were found: 33 publications for Engineering, 99 for Higher education, 31 for Motivation models, 49 for Self-determination, 20 for Emotional intelligence, 20 for Metacognition, 30 for Technologies and 7 for ICT (these last two can be united around the concept of technological tools being 37 in total). The classification is not one by one since some works contain more than one of the concepts analyzed; for this reason, the sum of all of them exceeds the total number of 132 publications.

The following subsections summarize the proposals that sequentially address the research questions: RQ1, RQ2, RQ3, and RQ4.

4.1. General Graphs

Regarding the classification of 132 publications, the number of publications per year can be identified according to Figure 6.

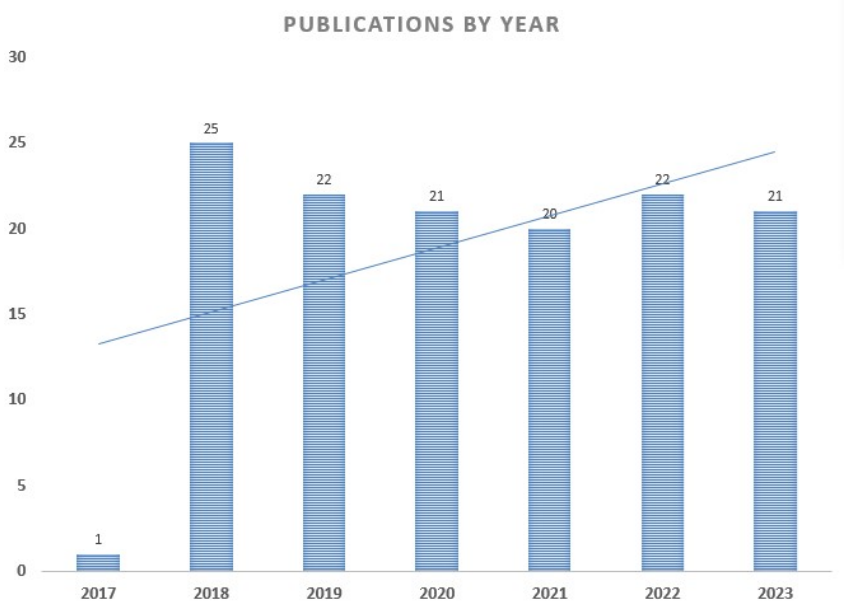

Figure 6. Quantity per year of publication.

Concerning the classifications, for the total of 132 publications, the percentage by type of publication can be identified as shown in Figure 7.

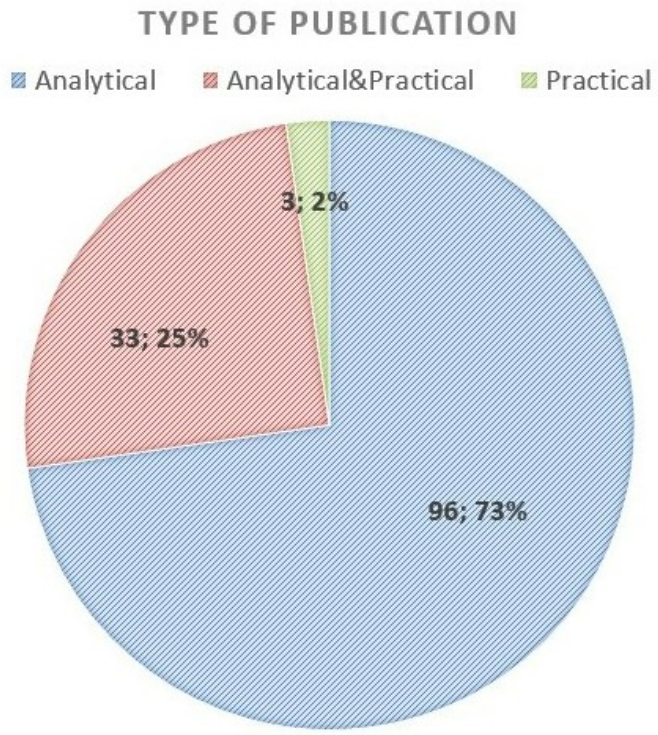

Figure 7. Percentage by type of publication.

Concerning the classifications for 132 publications, the percentage by publication category can be identified as shown in Figure 8.

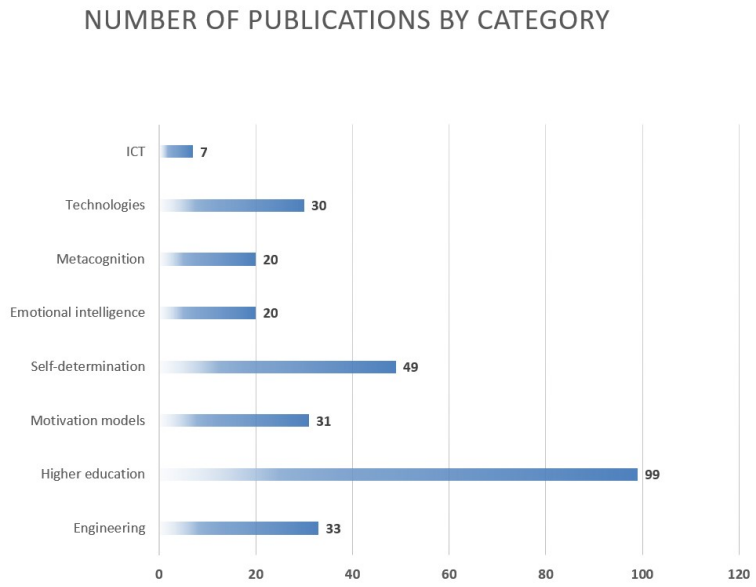

Figure 8. Number of publications per category.

From the graphs, we can observe that the subject of the study is very relevant and has gained greater importance since the COVID-19 pandemic, which had a strong impact on teaching and learning, betting on new models and strategies for the management of learning and motivation. Finally, the study will highlight relevant initiatives and the most widely used technological tools. It will also identify learning models that seek to link emotional intelligence, self-determination, cognitive skills, and ICT.

4.2. Results in Line with the Research Questions

Results for RQ1: How many of the selected papers address initiatives related to improving the learning motivation of higher education students in engineering?

To answer this research question, 31 papers on the subject were analyzed. In Table 4, we describe a list of the most representative cases and a description of the publications that characterize initiatives contributing to this research:

A list of the most representative cases and a description of the publications that characterize initiatives contributing to this research.

Table 4. Description of the most representative studies related to RQ1.

Ref.	Description
[29]	The lack of preparation of engineering students to address the problems identified in the industry represents a significant deficiency in higher education. The fundamental root of this lack of preparation lies in the fact that the "problems" to be solved in the working environment, in the real world, differ considerably from the traditional problems presented in textbooks in the classroom. A strategy for assessment was developed as an intervention, which incorporated a series of online self- and peer-assessments (formative assessments conducted online with guidance from the teacher). This approach culminated in creating a final industrial-style report that presented a possible solution to the problem. The teacher's intervention aimed to foster metacognition and enhance students' problem-solving abilities. The study's outcomes demonstrated a certain level of success for the teaching intervention known as "assessment as learning" (AaL), as it facilitated metacognition among students, which is crucial for tackling complex, ill-defined problems. Additionally, this research emphasized the significance of feedback in the learning process.
[30]	The study addressed how, during the pandemic crisis, the learning process took place online through platforms such as e-learning, Google Meetings, and Zoom. A model was developed to measure higher education self-efficacy, digital literacy, and metacognition, specifically focusing on university students. In addition, a metacognitive structural model was created. The research design employed predictive methods to assess how self-efficacy and digital literacy influence metacognition in the context of online learning.

Table 4. *Cont.*

Ref.	Description
[31]	According to another relevant study related to the COVID-19 pandemic, blended learning has become widely adopted, particularly in higher education. This situation led to the introduction of many university students to this learning approach. To analyze this situation, the researchers employed structural equation modeling to test a model that combined intrinsic motivation and academic self-efficacy into the Expectancy-Confidence model, specifically the Expectancy-Confirmation Model of Information System Continuity. The study's findings revealed that performance expectancy, intrinsic motivation, and satisfaction significantly influenced the continuance intention of novice learners engaged in blended learning. On the other hand, the study found that academic self-efficacy does not directly impact the continuance intention of university students. However, it does have an indirect influence through intrinsic motivation. In other words, higher academic self-efficacy leads to increased intrinsic motivation, which, in turn, affects the student's intention to continue with blended learning. In conclusion, the study provides valuable suggestions for educators to enhance the blended learning experience of novice learners. By implementing these recommendations, educators can foster a more engaging and supportive learning environment, encouraging students to continue participating in blended learning.
[32]	This study specifically focuses on the field of computer engineering, which is known for employing competency-based models. The researchers argue that the outcome expectations for Information Systems (IS) programs should be streamlined to focus on IS competencies. Individual core competencies are expected to be increasingly crucial in this context. According to the World Economic Forum's Future of Jobs report, there is a projected rise in the significance of specific skills in the job market. Complex problem-solving, soft skills, process skills, and systems skills are expected to gain prominence. Consequently, the demand for these skills, such as soft skills, complex problem-solving, process skills, and systems skills, is anticipated to surpass physical or content-based skills.
[33]	In this study, conducted in a higher education institution within the GCC (Gulf Cooperation Council) region, the impact of Problem-Based Learning (PBL) on students' motivation to learn was investigated using the framework of Self-Determination Theory (SDT). The main objective was to longitudinally analyze changes in students' perceptions of three psychological needs in SDT (perceived autonomy support, competence, and peer relationship learning) and students' learning motivation. The researchers compared students' perceptions after completing the first semester with their perceptions after completing the third semester. The results indicated a notable improvement in students' motivation for learning and a significant increase in their perceived autonomy support. Additionally, the study revealed that students attribute their perceived competence more to the support provided by learning facilitators rather than their peers. Furthermore, perceived competence positively impacted students' learning motivation, suggesting that when students feel competent in their learning, it enhances their motivation to continue learning.
[34]	The research investigates the enhancement of students' learning and performance by analyzing their motivation through learning analytics. The gathered data will be utilized to develop a structural equation model. Additionally, the study identifies students' motivational factors and customizes their learning approaches accordingly.
[13]	Regarding self-efficacy, in a study that employed the PMT (Protection Motivation Theory) to comprehend behavioral change after the introduction of cybersecurity training, it was observed that self-efficacy played a crucial role as a predictor of cybersecurity behavioral intention in both the pre-test and post-test PMT models. The study revealed that self-efficacy remained a significant predictor of cybersecurity behavioral intention across pre-test and post-test PMT models. Furthermore, the cybersecurity training significantly increased students' self-efficacy, which in turn contributed to the observed change of cybersecurity behavioral intention.
[35]	In the field of basic sciences, this research explored the correlation between motivational factors and students' learning achievement in Applied Calculus courses using the framework of self-determination theory. In order to obtain a comprehensive picture of students' motivation and learning, three different learning metrics were used to assess their mathematics performance. These metrics comprised course grades, a standardized knowledge test, and students' self-reported perception of knowledge transfer. Through a series of multilevel model analyses, it was discovered that (1) among college students, competence satisfaction plays a more significant role in predicting mathematics performance compared to autonomy and relatedness need satisfaction, and (2) autonomous motivation has a greater predictive power for college students' mathematics performance when compared to controlled motivation. Importantly, these findings remain consistent across various types of learning outcomes.
[36]	In this study, the feedback aspect is emphasized while not explicitly presented as a model. Research has demonstrated that high-quality feedback is crucial in fostering authentic learning. It achieves this by enhancing students' metacognitive skills and offering clear performance indicators and specific areas for improvement, thus facilitating their overall learning process.

Figure 9, from the Word Cloud for RQ1, shows the graphical representation of the initiatives associated with the results of the research question: Learning models.

Figure 9. Word cloud associated with the results associated with research question RQ1: Learning models.

Results for RQ2: For related papers, how many address innovative techniques on self-determination and/or emotional intelligence?

To answer this research question, 49 papers were analyzed that dealt with the subject of self-determination and 20 that dealt with the subject of emotional intelligence. Of these, in Table 5 we present a list of the most representative cases and describe the publications that present and contribute to the theme of self-determination, including the theme of emotional intelligence:

Table 5. Description of the most representative studies related to RQ2.

Ref.	Description
[37]	This study reveals that the COVID-19 pandemic has created uncertainty regarding the best academic strategies for students to excel, potentially affecting student retention, as per the self-determination and student-centered learning theory. What makes this study intriguing is its use of qualitative analysis, employing text and sentiment analysis tools to gain valuable insights into the situation. By employing these innovative methods, the study sheds light on the challenges students face during the pandemic and how it impacts their academic performance and persistence. The research findings indicated that, in addition to the conventional strategies for academic success in face-to-face courses, participants emphasized the importance of specific actions for effective online learning. These included the significance of taking notes, utilizing digital tools to enhance learning, and creating a dedicated study space at home. Regarding well-being, participants offered valuable recommendations to maintain a positive outlook. They advised focusing on positive situations, maintaining a healthy diet, getting sufficient rest, and taking breaks from extended computer use to support overall well-being during online learning.
[38]	From the self-determination theory (SDT) standpoint, this research illustrates how student engagement can be interpreted through fulfilling their needs. Consequently, this project aimed to explore how support from teachers based on SDT, along with student characteristics (such as gender and achievement level), influences AI learning. The findings imply that by concentrating on satisfying needs, boys, girls, and high and low achievers can be engaged in AI learning. When students become involved, they grow more confident, find the content pertinent, and are intrinsically driven to persist in learning AI.
[39]	The study's primary aim was to examine the subtle effects of creativity, the family entrepreneurial setting, and teacher innovation on the direct correlation between university students' self-efficacy and entrepreneurial goals. The findings validated that creativity positively and substantially impacts the student's belief in their abilities and intentions to become entrepreneurs. Additionally, the family's business background significantly and positively influenced self-efficacy. Conversely, the research demonstrated that creativity on the part of teachers does not enhance university students' entrepreneurial aspirations. In conclusion, the study notes that entrepreneurial students are more inclined to embark on a business venture.
[40]	The research illustrates that despite each discipline having its unique and specific knowledge, skills, and competencies, broader professional skills exist that traverse various disciplines, like empathy, emotional intelligence, and interprofessional abilities. These are more challenging to pinpoint. The study includes literature on these three distinct professional competencies—empathy, emotional intelligence, and interprofessional skills—and is primarily based on investigations centered on programs designed for health professionals.
[41]	The research explored three facets of Thai student–teachers' ability in self-directed learning, encompassing their perspectives on the utilization of social media (SM), self-direction (SM), and eagerness to learn (LD). The conclusive results from the second-order confirmatory factor analyses revealed that among the student-teachers, the self-directed learning (SDL) competency for self-control (SC) (0.96) was rated the highest. On the other hand, their abilities related to the aspiration to learn (AD) (0.87) and self-management (AD) (0.80) lagged. The Pearson correlation analysis (r) concerning the 24 variables' relationships indicated that the most potent variable connection was associated with each student-teachers inclination to learn. Conversely, the most feeble variable connection pertained to their capacity to establish elevated personal standards and the self-discipline required to reach them.
[42]	The study scrutinizes the chronological progression of students' methods, including their order, consistency, timing, and the likelihood of maintaining or modifying strategies across different courses. At the program level, three distinct strategies were discovered: a consistent and robust path associated with deep learning, where students utilized diverse strategies and attained the top grades; an inconsistent interactive path, where students concentrated on course necessities, secured average grades, and displayed relative fluctuation; and a superficial pathway tied to surface learning, where students exerted the least amount of effort, received the lowest grades, and followed a relatively stable trajectory.
[43]	The research explored factors (such as social interaction) and results (like self-directed study) related to online learning involvement during the first two years of the pandemic. Through multigroup path analysis, it was uncovered that online course interactions positively and indirectly influenced the time dedicated to self-directed study, facilitated through emotional and behavioral engagement in online learning.
[44]	The research examines the capabilities and prospects of using artificial intelligence (AI) techniques to evaluate self-reported protocols for identifying cognitive and metacognitive strategies in self-regulated learning. Within the study, 66 participants were enlisted to gauge the standard of scientific explanations, concurrently self-documenting their comprehension and rationale. Generally speaking, the AI classifier capably predicted cognitive or metacognitive strategies, even with a restricted dataset of 104 protocols from the 66 participants. Observations of a qualitative nature, aiming to elucidate the differences between human and computer interpretations, could illuminate paths toward enhancing AI-based techniques in the future. The study also explores the broader implications of AI in the context of self-regulated digital learning.

Figure 10, from the Word Cloud for RQ2, shows the graphical representation of the most recurrent and most straightforward applications for the results of the research question: Self-determination and/or emotional intelligence.

Figure 10. Word cloud associated with the results associated with research question RQ2: Self-determination and/or emotional intelligence.

Results for RQ3: How many of the selected papers demonstrate an impact on learning and attrition?

To answer this research question, we analyzed and filtered 132 papers, one by one, to identify which ones addressed the impact on learning and dropout. Of the total number of articles, only 19 were selected for analysis. Of these, in Table 6 we present the most representative studies.

Table 6. Description of the most representative studies related to RQ3.

Ref.	Description
[45]	This article focuses on student dropouts in science, technology, engineering, and mathematics (STEM). The experiences students encounter during their initial year of study play a pivotal role in shaping their motivation and, consequently, are essential elements of their academic triumph, influencing retention, learning, and future achievements. The research examines the motivational tendencies toward learning in two foundational courses attended by students across various study programs. It adds to the ongoing conversation about introducing interdisciplinarity and/or multidisciplinarity to students, highlighting the ramifications on two fronts: the curriculum structure and the content of individual courses.
[46]	The study reveals that although exploring STEM inclusion in higher education is somewhat novel, a substantial heritage exists in other disciplines. These areas have crafted authenticated theoretical models and tools to define and evaluate inclusion. According to self-determination theory (SDT), a strong connection exists between an individual's inner motivation and the fulfillment of three distinct psychological necessities: autonomy, competence, and relatedness. This article examines the linkage between inclusion and the continuous endeavors to augment the retention of students in STEM fields within higher education environments. Initiatives for inclusion enhance our comprehension of the underlying factors that influence their effectiveness, thereby promoting the potential for replication and broader applicability.
[47]	This study focuses on the critical role of metacognition in the performance of group learning. There is a recognized need to enhance group metacognitive scaffolding (GMS) within computer-supported collaborative learning (CSCL) contexts. The research aimed to broaden the prevailing comprehension of scaffolding in CSCL, exploring the influence of GMS on aspects like group metacognitive conduct, overall performance, and cognitive burden in CSCL settings. A total of 111 undergraduate students were part of the study, divided into small groups, and allocated to either experimental or control scenarios. Those in the experimental set were provided GMS during the online collaborative learning phase, while the control group engaged in online collaborative learning without GMS. The findings revealed that GMS had a notable effect on the transition and performance of the group's metacognitive behavior without adding to the student's cognitive load. The study concludes by discussing these results and their significance for educators and those developing these systems.
[48]	Recently, there has been a growing trend toward replacing or complementing teacher-centered educational strategies with student-centered approaches. Among these methodologies, problem-based learning and collaborative learning stand out. In certain areas, such as engineering, project-based learning leverages the advantages of problem-based learning and incorporates others relevant to the teaching of this discipline. Several European universities have recently demonstrated the success of project-based learning as a comprehensive strategy, with impressive results. Students who participate in this modality have lower dropout rates, adapt more quickly to professional practice and develop better interpersonal skills.

Results for RQ4: What technologies are being used, and what would be their most recurrent applications? Are they effective?

To answer this research question, 37 papers were analyzed that touched on the subject of. Of these, in Table 7 we present a list of the most representative cases, followed by a description of the publications that present and contribute to the subject of technologies, including the subject of applications, software, and current technological tools for effective learning.

Table 7. Description of the most representative studies related to RQ4.

Ref.	Description
[49]	The study points out that gamification has been used to stimulate students' interest in learning and increase their motivation by incorporating game design elements into the educational context. This research showed that gamification can effectively arouse interest in learning among underachieving students. To make a gamified learning platform motivate underachieving students to participate in online classes actively, it is required to include game elements such as meaning and purpose, start-up tutorials, social pressure, and the possibility of forming guilds or teams.
[12]	This study on gamification reveals that a group of students who experimented with the SGQ (student-generated questions) approach demonstrated a significant improvement in computational thinking abilities compared to a control group. Additionally, the experimental group surpassed the control group in terms of motivation and self-assurance in learning. This evidence supports the idea that incorporating the SGQ technique enhances students' advanced cognitive thinking in problem-solving via gamification. As a result, there is an increase in enthusiasm and confidence to undertake the activities within the experimental framework.

Table 7. *Cont.*

Ref.	Description
[14]	A study on virtual laboratories (VLs) use in elementary science education has identified a notable disparity in adopting this methodology, mainly attributed to a lack of awareness and familiarity between teachers and students. This research aimed to analyze the critical motivational factors affecting the effectiveness of VLs in teaching laboratory skills and tasks to students. The study revealed that educational resources with animated graphics in LVs significantly impacted students' intrinsic motivation more than e-book-based materials. In addition, it was found that conducting experiments in LV for extended periods or multiple times positively affected students' performance in the laboratory.
[50]	This model, founded on a human–robot interaction, employs a supervised learning algorithm to forecast student engagement. The experimental findings demonstrate that the suggested model is suitable for real-time implementation, with an anticipated prediction accuracy of 98.78%. The results further reveal that the proposed SEPM-HRI model enhances the learning rate to 94.26%, boosts the student engagement rate to 93.14%, and increases student participation rate to 92.86%.
[51]	This study highlights the necessity for further investigation into the connection between social media applications and the specific fields employed by these applications. The authors contend that identifying the key factors that affect the adoption of social media is vital.
[32]	The study reveals that RPL has enhanced the adaptability of curricula to accommodate both full-time and part-time students. Evidence of this can be seen in initiatives like EDUglopedia (2020), enabling universities around the globe to highlight and market their Information Systems programs.
[52]	The study outlines the findings of the "Mindsets STEM Enhancement Project". As part of this initiative, 57 novel resource packs were created and provided to London schools to augment STEM education, specifically in Design and Technology. An adapted Intrinsic Motivation Inventory questionnaire assessed pupils' motivation toward technology. The results indicate that while students respond favorably to the technical components in Design and Technology lessons, the specific STEM resources and lessons generated through the project could have been more influential in their interest and enjoyment of technology. This infers that stand-alone resources may have a different effect on enhancing students' motivation.
[53]	The study's primary aim is to assess the efficiency of SRSs (Student Response Systems) operated through smartphones in expansive undergraduate thermodynamics classrooms that demand advanced cognitive problem-solving abilities. By utilizing the monitoring features of the SRS, the study makes it possible to identify students who are having difficulty early on. This early detection then facilitates individualized tutoring, increasing student engagement and more effective participation in active-learning methods.
[54]	This study, of significant relevance, involves examining various modern technologies utilized in higher education framed through educational psychology theory. The aim is to shed light on the educational, cognitive, and socio-psychological dynamics that occur during the use of these technologies in teaching and learning. The study demonstrates how concentrating on these dynamics can enhance educational tools and improve learning results. Utilizing the Delphi method, a consensus was reached by a group of expert panelists through multiple rounds of commentary and voting on six technologies poised to substantially influence future education in higher education. These include (1) Adaptive Learning Technologies, (2) Artificial Intelligence (including applications based on machine learning), (3) Analytics for Student Success, (4) Elevating Instructional Design/Learning Engineering and User Experience (UX) Design in Pedagogy, (5) Open Educational Resources, and (6) X-Reality (XR) Technologies. Each technology category includes various products, each having unique features, employed across diverse educational settings to aid in teaching and learning across different academic fields. The study's importance lies in its summarization of the applications' goals and features and an analysis of the psychological procedures required to execute the specific educational tasks for which the technology is designed.

Figure 11, from the Word Cloud for RQ4, shows the visual representation of the technologies associated with the results of the research question: Most used technologies and their most recurrent applications.

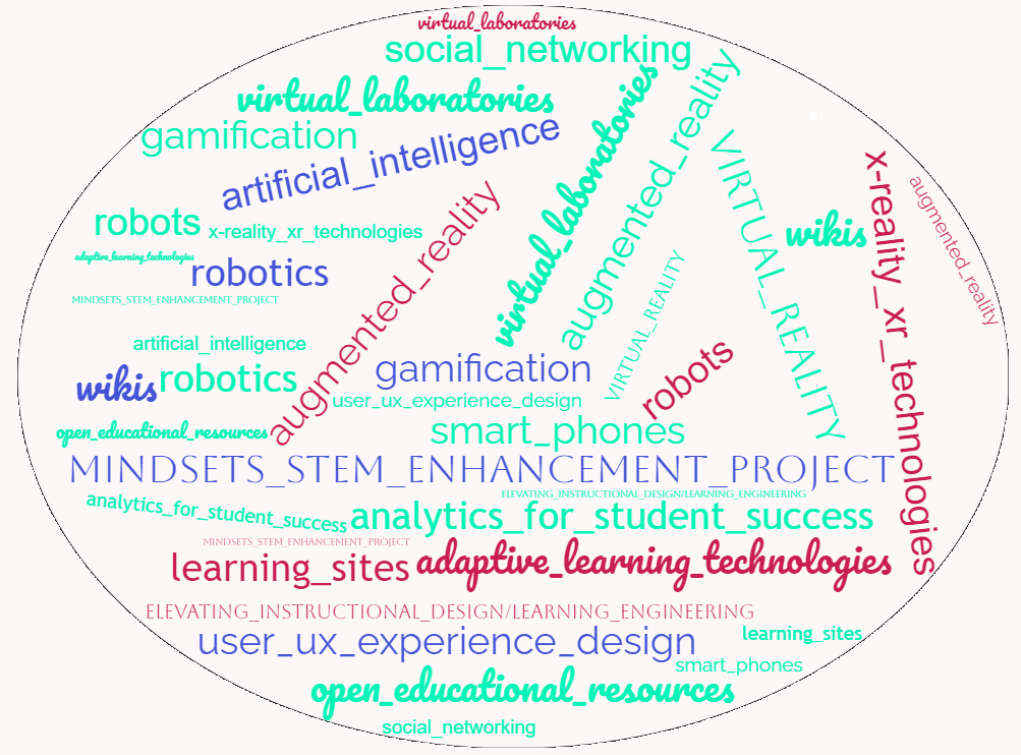

Figure 11. Word cloud associated with the results associated with research question RQ4: Most used technologies and their most recurrent applications.

5. Discussion

This study shows how self-determination theory is applied in engineering and how it contributes to the STEM domain. The study characterizes some motivational factors associated with students' learning outcomes. It also shows how students face the challenge of learning, considering personal skills, emotions, self-motivation, autonomy, competencies, and their own basic psychological needs, and looks at effective learning models based on the actual needs of students in a changing world using ICT.

Studies to date have pointed to the importance of metacognition in learning performance. However, more effort must be made to develop group metacognitive scaffolding (GMS) in computer-supported collaborative learning environments (CSCL). It is very relevant to continue investigating this type of study since the results indicated that GMS significantly impacted group metacognitive behavioral transition and group performance; it could be a fascinating future study [47]. The main contribution of this study was to propose a GMS approach and validate its effectiveness for metacognitive behavioral transition and group performance in an online collaborative learning environment.

Regarding technologies, beyond representing them in this section, the COVID-19 pandemic undoubtedly caused a turning point in technological issues associated with education. Universities, in general, were forced to adopt new technologies without knowing whether they were the most appropriate ones. This situation should be analyzed in each university in its particular version and planned alternatives for educational technologies. Their use should be proposed, not waiting for a new crisis that makes us manage solutions on the fly [30,31].

A relevant aspect for discussion is that it is clear that there is a fundamental need to define well-founded educational models, including implementation strategies focusing on skills, competencies, and their integration into university curricula so that students are better supported in their professional development.

Relevant aspects such as empathy, emotional intelligence, and inter-professional competencies transcend discipline-specific competencies, so all educators need to consider how best to foster them [40].

Another interesting point to mention is feedback; although it is not a model per se, many of the articles refer to the great relevance of feedback, which has long been recognized as a powerful tool for learning [55–57]. Feedback should be considered, as it plays an important role in acquiring knowledge and is a relevant factor that directly influences learners' motivation [58]. Studies have shown that high-quality feedback contributes to meaningful learning by promoting students' metacognitive skills and providing clear performance indicators and areas to track [10].

Although not explicitly detailed in the research questions, lab-based learning environments or coworking spaces offer a valuable opportunity for transformative and integrative value creation because of collaboration and interaction. The role of the teacher in this learning environment is to provide the basis for the process by facilitating and guiding. Given the right conditions, these learners can question underlying assumptions about how systems work and build trust by facilitating dialogue between societal actors [59].

In addition, it is essential to highlight the importance of prioritizing educational policies and teaching-learning methodology with a student focus, such as the flipped learning model, project-based learning, and problem-based learning [60]. The above is relevant because, while students may do their best to learn and stay on track, it is vitally important that all academics are attuned and aligned to institutional policies and highly motivated to be a fundamental part of the educational models. In one paper [61], data from a national online survey of 1671 lecturers from 19 universities were analyzed using structural equation modeling. The overall model showed that autonomy, competence, and teacher relatedness positively predicted autonomous (intrinsic, identified) motivation but not controlled (introjected, external) student motivation. Autonomous motivation, in turn, predicted greater incorporation of effective teaching strategies, namely clarity of instruction, higher-order learning, reflective and integrative learning, and collaborative learning.

Finally, the results show that performance expectancy, intrinsic motivation, and satisfaction significantly influence beginners' intention to remain in blended learning [62]. The permanence of students today is a very relevant issue that needs to be addressed responsibly and in depth.

6. Limitations of the Study

Although our goal was to provide a comprehensive literature review to contribute to future proposals involving the target topics of es: modeling, characterization of how students achieve more and better learning, self-determination theory and metacognition, emotional intelligence, and ICT/digital technologies in the context of engineering higher education, some limitations of the study should not be overlooked. Manipulating the databases manually through search engines to retrieve scientific articles and filtering the available literature by specific keywords could have some risks in extraction. They should be carefully analyzed to draw valid conclusions. In addition, our approach resulted in reviewing scholarly articles in English from 2018 without covering other languages that could contribute to the analysis. By employing this approach, we gathered articles from diverse journals and conferences, primarily of academic origin, focusing on the last five years to ensure the information's currency.

Nevertheless, filtering studies based on their publication timeframe and English language may result in chronological and geographical biases [63].

7. Conclusions

The authors offer an analysis of recent publications (last five years) that evaluate the use of learning models, aspects of motivation, self-determination, and technologies used to achieve learning in higher education focused on engineering. This topic is of great interest due to the emergence of new technologies that support the considering maintaining alertness for the analysis; factors such as personal skills, emotions, self-motivation, autonomy, competencies, and own basic psychological needs were supposed to propose effective learning models based on the needs of students in a changing world where ICT play a relevant role.

In conclusion, research has shown that students who have worked with effective learning strategies are more likely to achieve better academic results. Due to rapid technological and cultural changes, the traditional way of learning is no longer satisfactory. Technology, therefore, plays an important role in engineering education through the development of competencies. As argued by Sweller in Sweller [64], features of technologies designed to promote more effective learning often aim to foster psychological processes that are fundamental to learning and have been shown to produce specific academic outcomes [64]. This is why we reinforce that designing a good educational model must be carried out by multidisciplinary teams, investigating how these theories come together in various forms and applications using ICT to foster student motivation.

From the study, we observed conclusions that part of the main results is that most of the works are classified as theoretical or analytical, and very few incorporate a practical component. This suggests that empirical validation of the proposals is still needed, and further research is warranted to address how to knit or apply practical initiatives and evaluate their effectiveness. As the main conclusions regarding the results associated with initiatives related to improving the motivation of engineering students, it can be said that there are practical and sophisticated strategies, such as that predictive method to assess self-efficacy and digital literacy in metacognition in online learning; however, students highly value simple techniques such as feedback. The main conclusions regarding the results of the innovative self-determination and emotional intelligence techniques indicate that the weakest associated variables are related to the ability to establish high personal standards and the self-discipline to achieve them. Also, deep learning is obtained when several techniques are applied; students who use several strategies get the best grades, and consequently, students who invest the least effort obtain the lowest rates. As the main conclusions regarding the results of the studies that addressed the impact on learning and dropout, we find that students' experiences in their first year of studies are decisive, just as permanence increases with the implementation of inclusion initiatives. As the main conclusions regarding the results of the studies that addressed which technologies are used and which would be their most recurrent applications, we can identify AI, gamification, serious games, virtual reality, simulators, and robots.

Another important element is to consider that most of the studies reviewed concentrate only on analyzing one of the categories considered in this research. Only some of them consider a combination of two or more themes. It can be deduced from this that comprehensive solutions have yet to be proposed for combining the categories studied. Therefore, there is also yet to be specific knowledge about the interrelationships between these variables. Further research is therefore needed in this respect.

Despite the progress shown and related to the objective of the study, it is necessary to indicate that there are still many challenges which imply paying attention to some of the following aspects:

- collaboration between researchers in a multidisciplinary way when linking: engineering, higher education, psychology, and sociology,
- determining in more detail the measurable impact of various practices organized in student study cycles,
- the lack of particular or local characterization of student motivation and drop-out (presentation of results in terms of a lower drop-out rate),
- the analysis of the selection of technologies suitable for a particular environment, and
- the further engagement of the responsible actors (universities/faculties) in a technological environment promotes a better way of learning by detecting those who drop out in the process (drop-out).

In orientation for future research, we plan to conduct a broader literature review to identify additional factors or issues that will allow us to propose a local reference model to apply the strategies observed in this analysis, especially in applying technologies and their use in learning.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Articles used to Analysis and Results of systematic mapping.

Num.	Title	Cite	Year
1	Future engineers: the intrinsic technology motivation of secondary school pupils	[52]	2017
2	Impact of PBL on engineering students' motivation in the GCC region: Case study	[33]	2018
3	A Study on the Effectiveness of Entrepreneurship Education Programs in Higher Education Institutions: A Case Study of Korean Graduate Programs	[65]	2018
4	Examination of relationships among students' self-determination, technology acceptance, satisfaction, and continuance intention to use K-MOOCs	[66]	2018
5	Faculty members' motivation for teaching and best practices: Testing a model based on self-determination theory across institution types	[61]	2018
6	Gamified learning in higher education: A systematic review of the literature	[67]	2018
7	Investigation of community of inquiry framework in regard to self-regulation, metacognition and motivation	[68]	2018
8	Motivating factors of MOOC completers: Comparing between university-affiliated students and general participants	[69]	2018
9	Motivational predictors of students' participation in out-of-school learning activities and academic attainment in science: An application of the trans-contextual model using Bayesian path analysis	[70]	2018
10	Online e-learning and cognitive disabilities: A systematic review	[71]	2018
11	Predicting performance in health professions education programs from admissions information—Comparisons of other health professions with pharmacy	[72]	2018
12	Retrospective case studies of successful Chinese learners of English: Continuity and change in self-identities over time and across contexts	[48]	2018
13	Science teachers' practices: Teaching for self-regulated learning in relation to Pintrich and Zusho's (2007) model	[73]	2018
14	Self-assessment instrument to measure the competencies of Namibian graduates: Testing of validity and reliability	[74]	2018
15	Social, individual, technological and pedagogical factors influencing mobile learning acceptance in higher education: A case from Iran	[75]	2018
16	Students' math performance in higher education: Examining the role of self-regulated learning and self-efficacy	[76]	2018
17	Teaching Analytic Hierarchy Process (AHP) in undergraduate chemical engineering courses	[77]	2018
18	The current landscape of learning analytics in higher education	[78]	2018
19	To study or not to study geography? The changing motivations behind choosing geography degree programmes by Polish students in the years 1995–2015	[79]	2018
20	Transdisciplinarity in higher education for sustainability: How discourses are approached in engineering education	[80]	2018
21	Learning while creating value for sustainability transitions: The case of Challenge Lab at Chalmers University of Technology	[59]	2018
22	The efficacy of real-world experiences and service learning for fostering competences for sustainable development in higher education	[81]	2018
23	The roles of social influences on student competence, relatedness, achievement, and retention in STEM	[82]	2018
24	Added Benefits: How Supporting Women Faculty in STEM Improves Everyone's Job Satisfaction	[83]	2018

Table A1. *Cont.*

Num.	Title	Cite	Year
25	Marketable selves: Making sense of employability as a liberal arts undergraduate	[31]	2018
26	Massive Open Online Courses (MOOCs): Data on higher education	[84]	2018
27	Transformation of University Communication Strategy in Terms of Digitalization	[85]	2019
28	Background and enrollment characteristics of students with autism in higher education	[86]	2019
29	Engineering students' perceptions of the role of ESP courses in internationalized universities	[87]	2019
30	Methodologies for teaching-learning critical thinking in higher education: The teacher's view	[88]	2019
31	A race re-imaged, intersectional approach to academic mentoring: Exploring the perspectives and responses of womxn in science and engineering research	[89]	2019
32	Developing individual creativity for environmental sustainability: Using an everyday theme in higher education	[90]	2019
33	How does faculty research motivation type relate to success? A test of self-determination theory	[91]	2019
34	Investigating and fostering self-regulated learning in higher education using interactive ambulatory assessment	[92]	2019
35	Modeling temporal self-regulatory processing in a higher education biology course	[93]	2019
36	Project-led-education experience as a partial strategy in first years of engineering courses	[94]	2019
37	Strategic instrument or social institution: Rationalized myths of the university in stakeholder perceptions of higher education reform in Poland	[95]	2019
38	The effects of group metacognitive scaffolding on group metacognitive behaviors, group performance, and cognitive load in computer-supported collaborative learning	[96]	2019
39	The utility of self-determination theory in faculty of color's successful pursuit of tenure and promotion to the rank of associate professor	[47]	2019
40	The role of academic major and academic year for self-determined motivation in cooperative education	[97]	2019
41	Language learning among STEM students: motivational profile and attitudes of undergraduates in a UK institution	[98]	2019
42	Girls' video gaming behaviour and undergraduate degree selection: A secondary data analysis approach	[99]	2019
43	Motivational patterns in STEM education: a self-determination perspective on first year courses	[45]	2019
44	Mentors' Motivation to Address Race/Ethnicity in Research Mentoring Relationships	[100]	2019
45	An assessment of the level of emotional intelligence attributes of undergraduate built environment students in developing countries	[101]	2019
46	Reexamining the impact of self-determination theory on learning outcomes in the online learning environment	[102]	2019
47	Absent Autonomy: Relational Competence and Gendered Paths to Faculty Self-Determination in the Promotion and Tenure Process	[103]	2019
48	Construction of emotional intelligent service system for the aged based on Internet of things	[62]	2019
49	A Competency Model for Undergraduate Programs in Information Systems The Joint ACM/AIS IS2020 Task Force	[104]	2020
50	'Assessment as Learning' as a tool to prepare engineering students to manage ill-defined problems in industry	[29]	2020
51	Aprendizaje en línea durante la pandemia de COVID-19: Aplicación de la teoría de la autodeterminación en la 'nueva normalidad'	[105]	2020
52	A systematic review of audience response systems for teaching and learning in higher education: The student experience	[106]	2020
53	Emotional intelligence can make a difference in Engineering Students under the Competency-based Education Model	[107]	2020
54	English for specific playfulness? How doctoral students in Science, Technology, Engineering and Mathematics manipulate genre	[108]	2020
55	Enhancing the Quality of Engineering Learning through Skill Development for Feasible Progress	[109]	2020
56	Gamified crowdsourcing in higher education: A theoretical framework and a case study	[110]	2020
57	Introduction to systems engineering and sustainability PART I: Student-centred learning for chemical and biological engineers	[111]	2020
58	Introduction to systems engineering and sustainability part II: Interactive teaching of sustainability modeling by systems integration design for chemical and biological engineers	[112]	2020
59	Lithuanian case study on evaluating suitability, acceptance and use of IT tools by students—An example of applying Technology Enhanced Learning Research methods in Higher Education	[113]	2020
60	Motivation of higher education faculty: (How) it matters!	[114]	2020
61	Online learning during the COVID-19 pandemic: Applying the self-determination theory in the 'new normal'	[105]	2020

Table A1. *Cont.*

Num.	Title	Cite	Year
62	Open learner models in supporting self-regulated learning in higher education: A systematic literature review	[115]	2020
63	Psychological foundations of emerging technologies for teaching and learning in higher education	[54]	2020
64	Vuca in Engineering Education: Enhancement of Faculty Competency For Capacity Building	[60]	2020
65	The Relationship between Emotional Intelligence (EI) and the Malaysian University English Test (MUET) performance among technical students	[116]	2020
66	Connecting theory to practice: Using self-determination theory to better understand inclusion in STEM	[46]	2020
67	Pedagogies for employability: understanding the needs of STEM students through a new approach to employability development	[117]	2020
68	Self-determination impact on motivation in the conditions of professional education	[118]	2020
69	Online learning during the COVID-19 pandemic: Applying the self-determination theory in the 'new normal'	[119]	2020
70	Computing Competencies for Undergraduate Data Science Curricula	[120]	2021
71	Structural Model of Metacognition in Online Learning during the COVID-19 Pandemic	[30]	2021
72	Undergraduate's Perspective on Being an Effective Online Student During Lockdown due to COVID-19 Pandemic: An Educational Data Mining Study	[121]	2021
73	Developing a Learning Analytics Model to Explore Computer Science Student Motivation in the UK	[34]	2021
74	A Collaborative Model for Leadership Education in High-Potential University Women Students	[122]	2021
75	An explanatory sequential mixed-method research on the full-scale implementation of flipped learning in the first years of the world's first fully flipped university: Departmental differences	[123]	2021
76	Changes in motivation and its relationship with academic performance among first year chemical engineering students	[124]	2021
77	Comparative analysis of Student's live online learning readiness during the coronavirus (COVID-19) pandemic in the higher education sector	[125]	2021
78	Developing reflective engineers through an arts-incorporated graduate course: A curriculum inquiry	[126]	2021
79	Expectancy-value profiles in math and science: A person-centered approach to cross-domain motivation with academic and STEM-related outcomes	[127]	2021
80	From dispositions to positionality: Addressing dispositions of the student researcher in the ACRL framework	[128]	2021
81	Moderated Mediation Model of the Impact of Autonomous Motivation on Postgraduate Students' Creativity	[129]	2021
82	Perceptions of STEM alumni and students on developing 21st century skills through methods of teaching and learning	[130]	2021
83	The core components of education 4.0 in higher education: Three case studies in engineering education	[131]	2021
84	The role of emotional intelligence in student-supervisor relationships: Implications on the psychological safety of doctoral students	[132]	2021
85	An educational tool for enhanced mobile e-Learning for technical higher education using mobile devices for augmented reality	[133]	2021
86	How self-determination of scholars outclasses shrinking public research lab budgets, supporting scientific production: a case study and R&D management implications	[134]	2021
87	Use of a smartphone-based Student Response System in large active-learning Chemical Engineering Thermodynamics classrooms	[53]	2021
88	Engineering Students as Co-creators in an Ethics of Technology Course	[135]	2021
89	The use of augmented reality technologies in the development of emotional intelligence of future specialists of socionomic professions under the conditions of adaptive learning	[136]	2021
90	A self-determination theory (SDT) design approach for inclusive and diverse artificial intelligence (AI) education	[38]	2022
91	A systematic review of the role of learning analytics in enhancing feedback practices in higher education	[10]	2022
92	An Analysis of the Attitudes and Behaviours of University Students and Perceived Contextual Factors in Alternative Assessment During the Pandemic Using the Attitude–Behaviour–Context Model	[137]	2022
93	Analysis of the college underachievers' transformation via gamified learning experience	[49]	2022
94	CIST: A Serious Game for Hardware Supply Chain	[11]	2022
95	Evaluating protection motivation based cybersecurity awareness training on Kirkpatrick's Model	[13]	2022
96	Role of perceived self-efficacy in automated project allocation: Measuring university students—Perceptions of justice in interdisciplinary project-based learning	[138]	2022
97	Student support in higher education: campus service utilization, impact, and challenges	[139]	2022
98	Skillsets and attributes for enhanced teaching–learning outcomes at higher educational institutions in disruptive times	[140]	2022

Table A1. *Cont.*

Num.	Title	Cite	Year
99	Assessing the pre-conditions for the pedagogical use of digital tools in the Nigerian higher education sector	[141]	2022
100	Post-secondary career and technical education opportunities for adults with intellectual and developmental disabilities	[142]	2022
101	Computer-based business games in higher education: A proposal of a gamified learning framework	[143]	2022
102	Does design-build concept improve problem-solving skills? An analysis of first year engineering students	[144]	2022
103	Heutagogy: A self-determined learning approach for Midwifery Continuity of Care experiences	[145]	2022
104	How do adolescent mathematical self-concept and values explain attainment of different kinds of STEM degrees in adulthood?	[146]	2022
105	Human–robot interaction in higher education for predicting student engagement	[50]	2022
106	Influences of depression, self-efficacy, and resource management on learning engagement in blended learning during COVID-19	[147]	2022
107	Reflective Writing Supports Metacognition and Self-regulation in Graduate Computational Science and Engineering	[148]	2022
108	Sustainability courses in hospitality and tourism higher education: Perspectives from industry practitioners and students	[149]	2022
109	Competence and autonomous motivation as motivational predictors of college students' mathematics achievement: from the perspective of self-determination theory	[35]	2022
110	Metacognitive Awareness Perceptions of Students with High and Low Scores on TIMSS-Like Science Tests	[150]	2022
111	Intense, turbulent, or wallowing in the mire: A longitudinal study of cross-course online tactics, strategies, and trajectories	[42]	2022
112	Digital Transformation of Engineering Education for Smart Education: A systematic literature review	[151]	2023
113	A gendered perspective of challenges women in engineering careers face to reach leadership positions: A innovative theoretical model from Brazilian students' perceptions	[37]	2023
114	Creativity and the family environment, facilitators of self-efficacy for entrepreneurial intentions in university students: Case ITSON Mexico	[39]	2023
115	Educational assessment of 21st century skills—Novel initiatives, yet a lack of systemic transformation	[152]	2023
116	Empathy, emotional intelligence and interprofessional skills in healthcare education	[40]	2023
117	Enhancing student's computational thinking skills with student-generated questions strategy in a game-based learning platform	[12]	2023
118	How social media and peer learning influence student-teacher self-directed learning in an online world under the 'New Normal'	[41]	2023
119	Interaction during online classes fosters engagement with learning and self-directed study both in the first and second years of the COVID-19 pandemic	[43]	2023
120	Intrinsic and extrinsic motivation among students for laboratory courses—Assessing the impact of virtual laboratories	[14]	2023
121	Kinesic communication in traditional and digital contexts: An exploratory study of ESP undergraduate students	[15]	2023
122	Makerspace and robotics as/for STEM education	[153]	2023
123	Resilience in educational system: A systematic review and directions for future research	[154]	2023
124	Social media adoption in education: A systematic review of disciplines, applications, and influential factors	[51]	2023
125	Student motivation in STEM: factors related to and measurement of STEM motivation	[155]	2023
126	Teachers' mindset and attitudes towards learners and learning environment to support students' entrepreneurial attitudes in universities	[156]	2023
127	The design entrepreneur: How adaptive cognition and formal design training create entrepreneurial self-efficacy and entrepreneurial intention	[157]	2023
128	The effect of entrepreneurship education on the determinants of entrepreneurial behaviour among higher education students: A multi-group analysis	[158]	2023
129	The impact of CIE education integrated with the BIG 6 teaching strategy on students' innovative motivation, creativity, metacognition, and self-perceived employability	[159]	2023
130	Utilizing artificial intelligence to support analyzing self-regulated learning: A preliminary mixed-methods evaluation from a human-centered perspective	[44]	2023
131	Development of Metacognitive Skills through Digital Narratives in Higher Education	[160]	2023
132	Examining key factors of beginner's continuance intention in blended learning in higher education	[31]	2023

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