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Self-regulated learning in engineering students: A systematic review

Autorregulación del aprendizaje en estudiantes de ingeniería: Una revisión sistemática

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ABSTRACT:
The aim of this study is to characterize and identify limitations and orientations of empirical and quantitative research on self-regulated learning in engineering students through a systematic review. The main findings are that research in self-regulated learning in engineering students is at an initial level of development, and there are a low number of experimental studies. Therefore, universities have the challenge of promoting self-regulated learning in engineering students with intra-curricular interventions.
Keywords: Engineering, Higher Education, Self-regulated learning, Systematic review

RESUMEN:
El estudio tiene como objetivo caracterizar e identificar limitaciones y orientaciones de investigaciones empíricas cuantitativas sobre autorregulación del aprendizaje en estudiantes de ingeniería a través de una revisión sistemática. Los principales hallazgos muestran que la investigación sobre autorregulación del aprendizaje en estudiantes de ingeniería está en un nivel inicial de desarrollo y hay escasos estudios experimentales. Por lo tanto, las universidades tienen el desafío de promover la autorregulación del aprendizaje en estudiantes de ingeniería con intervenciones intra-curriculares.
Palabras clave: Ingeniería, educación superior, autorregulación del aprendizaje, revisión sistemática

1. Introduction

Engineering programs have high academic failure and drop out indicators, especially during the first semesters (Acevedo, Torres, & Tirado, 2015; García-Ros, Pérez-González, Cavas-Martínez & Tomás, 2018). This is due to the transition from high school to university, where students are exposed to a new culture that they don’t relate to and also that higher education requires having learning-autonomy (Gale & Parker, 2014; Graffigna et al., 2014).

Other aspects that have been studied in engineering programs are the way that students learn, depending on the course, and how they carry out their self-regulated processes (Capote, Rizo, & Bravo, 2017). Thus, evidence shows that 80% of engineering students have serious impairments in the use of self-regulated strategies, which results in low academic performances (Wisland, Duarte, & Yoshikazu, 2014). Studies also point out that students lack of study habits when starting college (Villalón, Medina, Sillero, Melchor, & Morales, 2017).

However, current demands of high-quality in Higher Education, require that university students develop self-regulated learning strategies and beliefs that will prepare them to solve problems, in the face of the challenges of autonomous learning (Capote, Rizo, & Bravo, 2017).

1.1. Promotion of self-regulation in engineering students, a challenge in Higher Education

Improvements have been made in engineering education. There has been progress in student-centered approaches, but these changes haven't been systemic and the studies have been mostly cross-sectional. Therefore, additional attention must be set on promoting more innovations (Borrego, Froyd, & Hall, 2010).

Hence, an important short-term goal in a university context is to promote new ways to learn, in order to face the challenges that come with autonomous learning (Villalón et al., 2017). From this perspective, SRL (Self Regulated Learnig) has proven to be a key factor for an effective performance and should therefore be included as a type of innovation in engineering circles (Capote et al., 2017). This helps students develop the ability to regulate their behaviors towards learning, learning difficulties and the way to overcome them (Lawanto et al., 2013).

Implementing interventions within engineering programs may prevent academic failure and early dropout (Acevedo et al., 2015). Interventions that emphasize the development and use of self-regulated learning strategies are crucial for the first semesters of engineering programs (Adams & Blair, 2019). In spite of the importance of promoting self-regulated learning in engineering students, it is still at an initial stage (Nelson, Shell, Husman, Fishman, & Soh, 2015).

A literature review is needed in order to have a clear notion of the current state of self-regulated learning research in engineering students. This will allow other researchers to have access to a more objective analysis of prior efforts, as well as the identification of gaps and the proposition of new directions for research (Borrego, Foster, & Froyd, 2014).

Thus, the following question arises: What are the characteristics, limitations and orientations of self-regulated learning research in engineering students? To answer this question this study has defined 3 objectives: (a) To characterize research on self-regulated learning for engineering students according to country of institutional affiliation of the main author, design, sample size, objective (s), variables (s), instrument (s) and result (s); (b) to describe the limitations of the studies and, (c) to identify recommendations for future research on self-regulated learning in engineering students.

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2. Methodology

This study considered preparation and writing guidelines for publications based on protocols, standards and stages suggested by specialized research in systematic review (Campbell, Taylor, Bates & O'Connor-Bones, 2018; Sánchez-Meca & Botella, 2010).

The two-stage process developed in this research is explained below. The first stage establishes a protocol for the search and selection of sources to analyze, and the second stage addresses protocols for the systematization of the information.

2.1. Stage 1: Search and selection of sources to analyze

This stage guides the whole review process, making its reproduction feasible through a five-step analysis protocol (see figure 1).

Step 1. Identification: Identification of the articles produced through a systematic search in the electronic databases Web of Science and Scopus. To refine the search in both data bases, the keywords "Engineering", "Self-Regulated Learning" and "Higher Education", related to the "AND" connector in English and Spanish were used for the time period going from 2007 to 2019. The last search date was held on June 16, 2019.

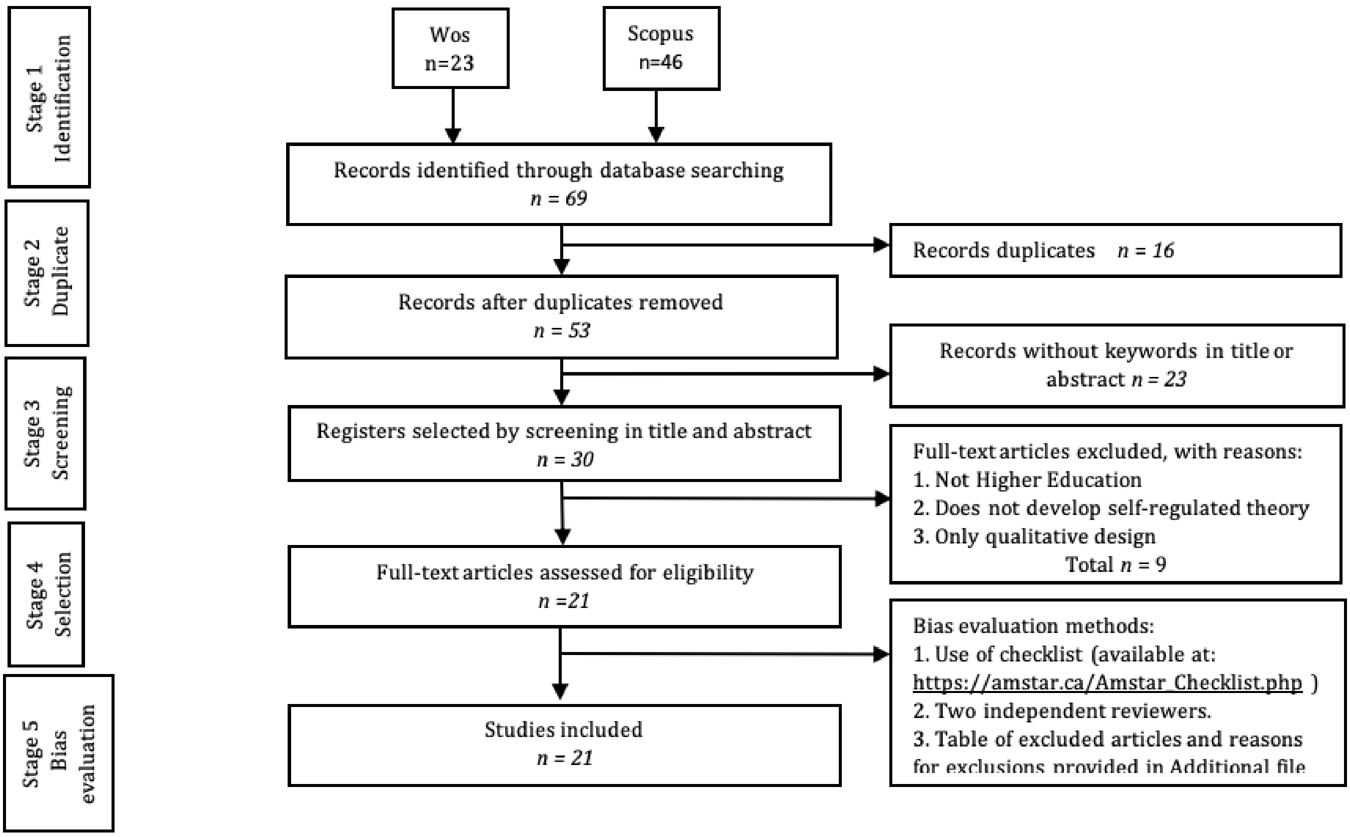
Step 2. Selection: When articles are found in both databases (they are duplicated), one of them is eliminated.

Step 3 Eligibility: In this phase, articles that did not contain the words "self-regulated learning" and "Engineering" in the title or abstract were not chosen.

Step 4. Inclusion: The inclusion criteria were: empirical quantitative and mixed research; Higher Education level; the sample or focus of the study must be university engineering students; and it must develop aspects of self-regulated learning theory. The exclusion criteria are the following: theoretical or empirical qualitative research; studies that are not for Higher Education levels (elementary or high school); articles that do not develop self-regulated learning theory; university students that are not from engineering programs.

Step 5. Bias evaluation: Three bias evaluation methods were used in order to ensure that the sample of articles went through a rigorous process: (1) The use of quality verification checklists or scales (available at https://amstar.ca/Amstar_Checklist.php), (2) the use of a third independent reviewer; (3) inclusion of the table of excluded articles with its exclusion justification.

Figure 1
Flow diagram of the search and selection of analyzed sources



2.2. Stage 2: Information systematization for data extraction

The following stage of the systematic review process considers the gathering of relevant information from each of the included articles. A matrix previously defined by the reviewers is used to gather all the relevant information for the analysis, synthesis and interpretation of the data. The matrix addresses the first research objective of this study, extracting the following information: Source, country, design, sample size, objective(s), variables(s), instrument(s) and result(s) reported in each study.

3. Results

3.1. Characteristics of the studies

Country

The country of Institutional affiliation of the main author of each study is shown in Table 1.

Table 1
Country of studies

Country	Nº of studies	%	Region	%		Country	Nº of studies	%	Region	%
United	10	48%	North	52%		Spain	1	5%	Europe	10%

States			America							
Mexico	1	5%				Italy	1	5%		
Colombia	1	5%				Turkey	1	5%		
Brazil	1	5%	South America	14%		Malaysia	3	14%	Asia	24%
Chile	1	5%				China	1	5%		
Total of studies: 21										

Design of the studies

8 studies used correlational design, 4 studies used mixed design (non-experimental and case study, descriptive and case study, quasi-experiment and phenomenological analysis, quasi-experiment and qualitative aspects) and 1 study used an experimental design. Quasi-experimental designs were used in 2 studies and explanatory models in two others. In addition, there were also a pre-experiment type study, a descriptive study, a descriptive-correlational study and an instrumental study. In summary, 13 studies (62%) had non-experimental designs (exploratory, descriptive, correlational-causal, instrumental), 4 studies (19%) used experimental design (quasi-experimental, pre-experimental and experimental) and 4 studies (19%) had mixed designs (qualitative and quantitative designs).

Sample size

The minimum sample size used in the studies was 15 students and the maximum was 1218. A sample size between 15 and 100 students was used in 9 investigations (43%); between 100 and 500 students also in 9 investigations (43%); between 500 and 1000 students in 2 investigations (10%) and a sample over 1000 students was used in one investigation (4%).

Objectives of the studies

Of the 21 objectives formulated in the studies, 15 of them (71%) were to describe or study relationships between the different SRL variables with academic performance, perceived social support of peers, learning approaches, interpretation of the demands of the task, composition of gender in the classroom, virtual learning environments and teaching strategies. Only 6 objectives (29%) consider evaluating the impact of interventions that consider the improvement of SRL variables in engineering students.

Variables considered in the studies

50 variables were identified in the 21 studies, whereas 9 of these were used in more then one study (8 variables were considered in 2 studies and 1 variable was considered in 9 studies). These variables were grouped in 6 categories: (1) self-regulated learning, (2) forethought phase, (3) performance phase, (4) self-reflection phase, (5) performance and (6) others. Categories 2, 3 and 4 correspond to Zimmerman’s model (Zimmerman, 2000)

Table 2
Variables and categories used in studies

Category	Studies that use the category		Variables	ID	Studies that use the variable	
	n	%			n	%
Self-regulated learning	12	57%	Self-regulated learning	3, 5, 10, 13, 14, 15, 17, 18, 19	9	14%
			Self-regulated learning skills in their online learning environment	20	1	2%
			Self-regulated learning strategies	12	1	2%

			Self-regulation strategies in reading	9	1	2%
Forethought phase	11	52%	Academic goals	9	1	2%
			Academic self-confidence	16	1	2%
			Extrinsic goal orientation	6	1	2%
			Goal-setting	2	1	2%
			Motivation	4, 5	2	3%
			Motivation for learning	21	1	2%
			Motivational Strategies	11	1	2%
			Perceived general self-efficacy	18	1	2%
			Planning strategies	7	1	2%
			Self-efficacy	16	1	2%
			Self-efficacy beliefs in the use of educational internet	19	1	2%
			Self-motivation	1	1	2%
Performance phase	10	48%	Action control	21	1	2%
			Cognitive	4	1	2%
			Critical thinking	6, 16	2	3%
			Environment structuring	2	1	2%
			Help seeking	1, 2	2	3%
			Learning approaches	8, 13	2	3%
			Learning strategies	8, 21	2	3%
			Metacognition	6	1	2%
			Monitoring strategies	7	1	2%
			Peer social support	13	1	2%
			Regulation strategies	7	1	2%
			Resource management	4	1	2%
			Search for help	16	1	2%
			Task interpretation	12	1	2%

			Task strategies	2	1	2%
			Time management	1, 2	2	3%
Self-reflection phase	2	10%	Self-evaluation	1, 2	2	3%
Other	9	14%	Knowledge activation	1	1	2%
			Previous knowledge	9	1	2%
			Academic integration	16	1	2%
			Affection	5	1	2%
			Discrimination	16	1	2%
			Effort	16	1	2%
			Effort investment	1	1	2%
			Information literacy	19	1	2%
			Learning experience	3	1	2%
			Peer learning	6, 16	2	3%
			Perceived benefit	3	1	2%
			Perception teacher support	6	1	2%
			Personality traits	21	1	2%
			Satisfaction	3	1	2%
			Student gender balance	11	1	2%
Performance	2	3%	Academic performance	3	1	2%
			Performance criteria	12	1	2%
	46	183%			66	100%

Instruments used in the studies

Self-regulated learning: (1) 3 phase SRL self-assessment instrument; (2) Escala de Evaluación de la Autorregulación del Aprendizaje a partir de Textos (ARATEX) (Text based Self-Regulated learning Scale); (3) Self-regulated learning survey: Engineering Design Questionnaires (EDQ); (4) Self-regulated learning skills scale; (5) Online Self-regulated Learning Questionnaire (OSLQ); (6) Student Perceptions of Classroom Knowledge Building scale (SPOCK); (7) Tracking of Supervised Learning Activities (TSLA) and (8) Ex-ante and Ex-post Survey (EAS & EPS).

Motivation: (1) Situational Motivation Scale (SIMS); (2) Motivated Strategies for Learning Questionnaire (MSLQ); (3) Questionnaire for the Evaluation of Academic Goals (CEMA). (4) Positive and Negative Affect Scale (PANAS); (4) Perceptions of instrumentality (PI). The instrument most used to measure motivation was MSLQ, which was used 9 times.

Strategies: (1) Cuestionario de Evaluación de las Estrategias de Aprendizaje de los Estudiantes Universitarios (CEVEAPEU) (University Students' Learning Strategies Questionnaire); (2) Learning and Study Strategies Inventory (LASSI); (3) Learning strategies Scale; (4) Inquiry Learning Questionnaire (ILQ).

Self-efficacy: (1) Perceived General Self-Efficacy Scale; (2) Belief scale of self-efficacy in the use of educational internet; (3) Cooperative Institutional Research Program scale (CIRP).

Learning approaches: (1) Cuestionario de Procesos de Estudio (CPE) (Study Process Questionnaire); (2) Study Process Questionnaire (R-SPQ-2F).

Ten other instruments were used for specific variables that were used in just one study: (1) Learning Climate Questionnaire (LCQ) that measures the teacher's perceived support for autonomy; (2) Multidimensional Scale of Perceived Social Support (MSPSS) to measure peer social support; (3) Santiago and Einarson scale to measure academic integration; (4) Scale of perceived discrimination to measure this variable; (5) Information Literacy Scale; (6) Mini marker scale to measure personality traits; (7) Action Control Scale; (8) Learning experience questionnaire; (9) Perceived benefit questionnaire; (10) Satisfaction questionnaire.

Results of the studies

Descriptive, correlational, instrumental, explanatory and causal results were identified, which is consistent with the designs and objectives proposed in the studies.

The descriptive studies showed the following results: (1) Engineering students have a low level of self-regulated learning (Hafizah et al., 2016); (2) Engineering students do not plan or monitor their learning process (Zambrano, 2016).

Correlational studies showed the following relationships: (1) Students with maladaptive profiles learned less than those who adopted learning profiles (Nelson et al., 2015); (2) High levels of student learning are related to the development of self-regulation strategies (Ernst & Clark, 2014); (3) Gender balance in the classroom between students and their instructors is associated with the SRL behaviors and attitudes adaptation (Stefanou et al., 2014); (4) Higher performing students had a greater awareness and use of the monitoring and fixation strategies associated with success in the design process (Lawanto, Butler, Cartier, Santoso, & Goodridge, 2013); (5) The dimensions of self-regulated learning, information processing, motivation and self-examination are related to the deep learning approach. The perceived social support of peers is associated with the information and motivation processes dimension (Hafzan et al., 2015); (6) Significant relationships between SRL and academic performance (Kosnin, 2007); (7) Higher performance students outperformed those with lower performance significantly in: goal setting, frequency of access to all course materials, and in the punctuality of task presentation (Lawanto et al., 2014).

Causal or explanatory correlational studies had the following results: (1) The initial grade average, along with motivational factors such as goal orientation, significantly predict the use of self-regulated learning strategies in the comprehension of academic texts (Gaeta, 2015); (2) The lack of academic integration decreases self-efficacy and academic confidence; and academic integration has a positive effect on self-efficacy, which in turn has positive effects on effort and critical thinking (Vogt, 2008); (3) The educational use of internet and self-regulation skills have been considered effective in information literacy (Gunes et al., 2015); (4) Direct effects of student personality, motivation for learning and action control on self-regulated learning strategies (Chi-Tung & Ruey-Gwo, 2011).

The only study with instrumental design had as a result that the adapted instrument (MSLQ-Colombia) had acceptable psychometric properties of construct validity, content validity and reliability (Ramírez-Echeverry et al., 2016).

The non-experimental designs had the following results: (1) Significant differences at the end of the course between Problem Based Learning (ABP) courses and courses with active learning lectures; also the use of PBL (Problem-Based Learning) promoted critical thinking, the search for help and elaboration, while active learning lectures tend to promote a more effective use of time and study environment (Lord et al., 2012); (2) Significant improvements in learning strategies and deep learning post-test scores (Gargallo et al., 2015).

Quasi-experimental designs had the following results: (1) The implementation of self-regulated learning self-assessment has a high and significant impact on the performance of freshmen students and students that require further elaboration to achieve deep learning, but it had a mild impact in older students (Zheng et al., 2016); 2) the discipline integration project increases the following: Commitment to SRL, intrinsic motivation, value of the task, and the use of critical thinking strategies, in comparison to students from courses that don't have this project; 3) designs specifically tailored to implement self-regulated learning features in a web-enhanced active learning approach are effective in reinforcing professional knowledge and fostering SRL (Manganello, Falsetti & Leo, 2019).

The experimental design had as a result that learning analytics can be used to promote self-regulated learning in flipped classrooms, helping students to identify strategies that can increase their academic performance (Sedraz et al., 2018).

3.2. Limitations

Of the 21 investigations included in this research, only 13 (62%) of them explicitly reported and informed the limitations of their work. The other 8 investigations did not inform it. This does not mean that the other investigations didn't have any limitations, however, for analysis purposes only those that were reported by the authors were considered.

The limitations reported were grouped in the following 5 categories: (1) study design, (2) type of self-report instrument, (3) sample used, (4) measurement of achievement and student learning, (5) measurement and analysis of only some SRL variables.

Table 3
Limitations of studies

Category	n	%	Limitation	ID	n	%
Study design	5	38%	Not controlling previous group differences by design	3	1	8%
			Regarding student profile analysis, although it's a highly interpretative descriptive methodology, it is not an inferential statistical technique of the data obtained and also does not control the differences between instructors or methodologies used in the classes	5	1	8%
			Application of pre-experimental designs that did not consider a control group	8	1	8%
			Exploratory type designs	12	1	8%
			Transversal non-longitudinal designs that condition the accuracy of the results and their generalization	16	1	8%
Type of self-report instrument	5	38%	Self-report instruments may possibly have subjective biases, since they do not provide complete information of the student's self-regulated behaviors. Therefore, considering only this method of evaluation is not enough to examine in detail the strategies of self-regulation and it is insufficient to fully capture the complexity of real classroom situations and direct information of self-regulated behaviors	12, 7, 6,4, 3	5	38%
Sample used	12	92%	Sample is not representative because it does not examine the impact on students from other populations	2, 3	2	15%
			Sample is not representative because it does not consider other courses at the university	9, 4	2	15%
			Sample is not representative because it does not consider other universities	8, 5	2	15%
			the second reason is the small size of the sample	10, 12, 7	3	23%

			and the third reason is the use of convenience sampling	6, 16	2	15%
			or arbitrary sampling of the participants	14	1	8%
Measurement of achievement and student learning	1	8%	Not measuring students' achievement or learning	1	1	8%
Measurement and analysis of only some of the SRL variables	1	8%	Measurement and analysis of only some SRL variables.	9	1	8%

3.3. Studies' guidelines

Of the 21 studies included in this investigation, 14 of them (67%), report orientations or guidelines for future research, which were grouped in the following: (1) more rigorous experimental design, (2) longitudinal studies, (3) reliable instruments that measure the SRL process, (4) larger samples through random selection that takes into consideration other populations, (5) study of self-regulation profiles, (6) that universities take on the challenge of promoting SRL in engineering students with intra-curricular interventions.

Table 4
Guidelines of the studies

Category	n	%	Guidelines	ID	n	%
More rigorous experimental design	6	43%	The design must be rigorous in terms of the participants.	3	1	7%
			There should be a combination of methodologies applying mixed designs to better understand students' SRL processes.	7, 20, 4	3	21%
			To perform quasi-experimental designs with control groups in order to compare the results and also to evaluate the impact of interventions in engineering students' SRL.	8, 17	2	14%
Longitudinal studies	4	29%	Follow-up objectives involving longitudinal studies were proposed to evaluate the use of SRL strategies in future courses.	7, 20, 3	3	21%
			To verify the causality of the variables.	16	1	7%
Reliable instruments that measure the SRL process	4	29%	To collect data with more reliable instruments and to use technology to register it.	3	1	7%
			To use instruments that evaluate the use of the strategy in real time, complementing the evidence generate by the "self-report", that is, measure through direct observations of students' behavior to identify SRL behaviors.	14, 12, 6	3	21%
Larger samples	5	36%	To increase the representativeness of the	9, 4	2	14%

through random selection that takes into consideration other populations,			participants considering other populations.			
			To use random and not by convenience samples.	6	1	7%
			To increase the sample size to have more diverse contexts in the understanding of SRL and thus be able to generalize the results.	10, 8, 12, 7, 20	5	36%
Study of self-regulation profiles	2	14%	The development of a comparative study to examine SRL processes in first-year engineering students and in students from higher years.	12, 5	1	7%
That universities take on the challenge of promoting SRL in engineering students with intra-curricular interventions	8	57%	That universities promote SRL in engineering students with intra-curricular interventions, especially in the first year.	21, 17, 14, 12, 20, 16	6	43%
			That the interventions include teachers in the promotion of SRL.	9, 5	2	14%

4. Conclusions

The three objectives of the study are discussed below:

(a) Characterization of research on self-regulated learning in engineering students: Research of self-regulated learning in engineering students is led by the United States with more than 48% of the total research. In Latin America, only four investigations were found, representing 19% of the total research. This is consistent with findings in previous studies, regarding the low amount of research in engineering in Latin America (Hernández & Camargo, 2017). The most frequent design observed in the studies is correlation, followed by a much lower number of quasi-experimental studies. This may be seen as a weakness in the type of design in terms of the low amount of interventions carried out in the classroom. This is relevant because it is precisely in the classroom where self-regulated learning must be encouraged so that students become aware of their learning process (Merchán and Hernández, 2018).

(b) Limitations of the studies: The most frequently reported limitation was regarding the representativeness of the sample. This was followed by the design of the study and the use of only self-report instruments.

(c) Guidelines: The main recommendations are as follows: Universities should develop action plans to promote SRL in engineering students with intra-curricular interventions; there should be more studies with quasi-experimental designs and larger samples, and finally, more studies with longitudinal designs are needed.

It is reasonable to conclude that research in self-regulated learning in engineering students is at an initial level of development. Another interesting fact is that research in the field of engineering education focuses mainly in the areas of active learning, curriculum and others, but not on psychological aspects of learning, such as self-regulated learning (Borrego et al. al., 2014; Borrego et al., 2015; Jesiek et al., 2011).

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Annexes

Appendix 1

Exclusion criteria for articles that were not included in the systematic review

Articles eliminated in the eligibility stage by exclusion criteria:
Level of studies other than Higher Education

1	Han, S. (2017). Korean Students' Attitudes toward STEM Project-Based Learning and Major Selection. *Educational Sciences: Theory & Practice*, *17*(2). DOI: 10.12738/estp.2017.2.0264
2	Barak, M. (2012). From 'doing'to 'doing with learning': Reflection on an effort to promote self-regulated learning in technological projects in high school. European Journal of Engineering Education, 37(1), 105-116. 10.1080/03043797.2012.658759
3	Lawanto, O., Santoso, H. B., & Liu, Y. (2012). Understanding of the relationship between interest and expectancy for success in engineering design activity in grades 9-12. Educational Technology & Society, 15(1), 152-161
	Articles eliminated in the eligibility stage by exclusion criteria: *Does not develop the self-regulated learning theory, does not measure self-regulation variables*
4	Gonzalez Hernandez, W. (2016). Modelling as a Competency for the Training of Computer Professionals. REVISTA DIGITAL DE INVESTIGACION EN DOCENCIA UNIVERSITARIA-RIDU, 10(2), 59-71. Doi: 10.19083/ridu.10.493
5	Yan, C. (2014). Research-oriented English teaching of engineering majors at regional Chinese engineering colleges based on the idea of steps. World Trans. on Engng. and Technol. Educ, 12(4), 753-758.
6	Sáiz Manzanares, M. C., & Bol Arreba, A. (2014). Learning based on assessment with rubrics: a study in higher educatio. Suma Psicológica, 21(1), 28-35.
7	Cubero, S. N. (2015). A fun and effective self-learning approach to teaching microcontrollers and mobile robotics. International Journal of Electrical Engineering Education, 52(4), 298-319. Doi:10.1177/0020720915585798
8	Zheng, W., Shih, H. R., Lozano, K., & Mo, Y. L. (2011). Impact of nanotechnology on future civil engineering practice and its reflection in current civil engineering education. Journal of Professional Issues in Engineering Education and Practice, 137(3), 162-173. DOI: 10.1061/(ASCE)EI.1943-5541.0000034

Articles eliminated in the eligibility stage by exclusion criteria: *Only qualitative design*

9	Pedrosa, D., Cravino, J., Morgado, L., & Barreira, C. (2017). Self-regulated learning in higher education: strategies adopted by computer programming students when supported by the SimProgramming approach. Production, 27(SPE).

Appendix 2

Article information Matrix

ID	Reference	Country	Design/n	Objective (s)	Variable(s)	Instrument	Results
1	(Manganello, Falsetti & Leo, 2019)	Italy	Mixed (Quasi-experimental & qualitative aspects) (n=418)	To implement a web-enhanced active learning approach to reinforce professional knowledge and foster their ability of self-regulated learning.	1. Self-motivation 2. Knowledge activation 3. Time management 4. Help seeking 5. Effort investment 6. Self-evaluation	1. EAS (Ex-ante survey) 2. TSLA (Tracking of Supervised Learning Activities	The results of the study confirmed the effectiveness of a learning design specifically tailored to implement self-regulated learning features in a web-enhanced active learning approach.
2	(Sedraz, Zambom, Lins, Cavalcanti & da Fonseca, 2018)	Brazil	(Experimental) (n=96)	To analyze the effects of learning analytics on students' self-regulated learning in a flipped classroom.	1. Goal-setting 2. Environment structuring 3. Time management 4. Help-seeking 5. Task strategies 6. Self-evaluation	Online Self-Regulated Learning Questionnaire (OSLQ)	Learning analytics can be used to promote self-regulated learning in flipped classrooms, helping students identify strategies that can increase their academic performance.
3	(Zheng, Yin, Shi, & Skelton, 2016)	United States	Quasi-experimental (n=206)	To implement a framework to help students experiment SRL processes, and deep learning of engineering concepts and principles.	1. Self-regulated learning 2. Academic performance 3. Satisfaction 4. Learning experience 5. Perceived benefit	1. 3 phase SRL self assessment instrument 2. Satisfaction questionnaire. 3. Learning experience questionnaire 4. Perceived benefit questionnaire.	Implementation of self-assessment of self-regulated learning has a high and significant impact on the performance of freshmen students and students that require further elaboration to achieve deep learning and mild learning in the case of older students.
4	(Stolk & Martello, 2015)	United States	Quasi-experimental (n=114)	To investigate the effects of different levels of disciplinary integration through projects on motivation and commitment to student learning.	1. Motivational variables. 2. Cognitive variables. 3. Resource Management Variables	1. Situational Motivation Scale (SIMS) 2. Motivated Strategies for Learning Questionnaire (MSLQ)	Discipline integration project increases in students: 1. Commitment towards SRL 2. Intrinsic motivation and value of the task; 3. The use of critical thinking strategies; compared to students from courses without this project.
5	(Nelson et al., 2015)	United States	Correlational (n=538)	To determine the motivational and self-regulated learning profiles that engineering students adopt in fundamental courses.	1. Self-regulation 2. Motivation and affection.	1. Student Perceptions of Classroom Knowledge Building (SPOCK) scale. 2. Perceptions of instrumentality (PI), adapted from the Future Time Perspective Scale. 3. Positive and Negative Affect Scale (PANAS).	1. Five learning profile groups. 2. Approximately 83% of engineering students in a computer science course adopted maladaptive profiles. These students learned less than those who adopted learning profiles.

6	(Lord, Prince, Stefanou, Stolk, & Chen, 2012)	United States	Mixed (Case study and non-experimental design). (n=176)	To determine how the instructor's choice of active learning pedagogies affects student outcomes in terms of their development as life long learners.	1. Metacognitive self-regulation 2. Peer learning 3. Critical thinking 4. Extrinsic goal orientation 5. Perception of teacher support for student autonomy	1. MSLQ 2. Learning Climate Questionnaire (LCQ)	1. The development of self-regulated students implies a complex interaction between many factors influenced by the teachers' design of the course. 2. Problem-based learning pedagogies promote significantly more critical thinking, the search for help and elaboration, while active learning lectures promote a more effective use of time and study environment
7	(Lawanto & Santoso, 2013)	United States	Mixed (Quasi-experimental and phenomenological analysis) (n=97)	To describe how the use of guided notes improved by the teacher, have an influence on students' self-regulated learning strategies, student learning and grades.	1. Planning strategies 2. Monitoring strategies 3. Regulation Strategies	Inquiry Learning Questionnaire (ILQ)	1. Taking notes using improved guided notes increases performance in exams. 2. Students that improved SRL obtained higher scores than those who decreased SRL in the areas of planning, monitoring and regulation strategies, after using the improved guided notes.
8	(Gargallo, Morera, & García, 2015)	Spain	Pre- experiment n=20	To assess the impact of a learning centered methodology on learning strategies and learning approaches in university students.	1. Learning strategies 2. Learning approaches	1. Cuestionario de Evaluación de las Estrategias de Aprendizaje de los Estudiantes Universitarios (CEVEAPEU) (Learning Strategies Evaluation Questionnaire for university students) 2. Cuestionario de Procesos de Estudio (CPE) (Study processes Questionnaire)	Significant improvements in learning strategies and deep learning post-test scores were obtained when using learning centered methodologies.
9	(Gaeta, 2015)	Mexico	Descriptive Correlational n=364	To analyze the predictive capacity of prior knowledge and academic goals with regard to self-regulation strategies involved in the deep understanding of reading, in university students.	1. Previous knowledge 2. Academic goals 3. Self-regulation strategies in reading comprehension	1. Cuestionario para la Evaluación de Metas Académicas (CEMA) (Academic Goals Evaluation Questionnaire 2. Escala de Evaluación de la Autorregulación del Aprendizaje a partir de Textos (ARATEX) (Text based Self-Regulated Learning Scale).	The initial grade average, along with motivational factors such as goal orientation, significantly predicts the use of self-regulated learning strategies in the comprehension of academic texts.
11	(Stefanou, Lord, Prince, & Chen, 2014)	United States	Correlational n=176	To examine the relationship between the personal factors that identify a self-regulated student and the environmental factors related to the gender composition of the engineering classrooms.	1. Student gender balance in the course (IV) 2. Motivational strategies and orientations (DV)	MSLQ	A gender balance in the classroom between students and their instructors provides the adaptation development of SRL behaviors and attitudes.
12	(Lawanto, Butler, Cartier, Santoso, & Goodridge, 2013)	United States	Correlational n=70	To explore differences in SRL for high and low performance students in the interpretation of task demands.	1. Task Interpretation 2. Self-regulated learning strategies 3. Performance criteria	Self-regulated learning survey: Engineering Design Questionnaires (EDQ)	Higher performance students had a greater awareness and use of the monitoring and fixation strategies associated with success in the design process.
13	(Hafzan, Nasirah, Norida, & Kalthom, 2015)	Malaysia	Correlational n=93	To examine the relationship between perceived peer social support, learning approaches and self-regulated learning dimensions.	1. Self-regulated learning. 2. Learning approaches 3. Peer Social Support	1. Learning and Study Strategies Inventory (LASSI) 2. Study Process Questionnaire (R-SPQ-2F) 3. Multidimensional Scale of Perceived Social Support (MSPSS)	1. The dimensions of self-regulated learning, information processing, motivation and self-examination are related to the deep learning approach. 2. The perceived social support of peers is associated with the information and motivation processes dimension.
14	(Kosnin, 2007)	Malaysia	Correlational n=460	To investigate the ability of self-regulated learning in predicting academic success in undergraduate students.	Self-regulated learning	MSLQ	Significant relationships between SRL and academic performance.
15	(Ramírez-Echeverry, García-Carrillo, & Olarted, 2016)	Colombia	Instrumental n=1218	To adapt and validate the MSLQ instrument for engineering students of a university in Colombia.	Self-regulated learning according to Pintrich's definition	MSLQ	The adapted instrument called MSLQ-Colombia has acceptable psychometric properties of construct validity, content validity and reliability.
16	(Vogt, 2008)	United States	Explanatory model (causal correlational) n=684	To study variables that influence engineering students' dropout using Bandura's (1986) cognitive social model as a theoretical framework	1. Self-efficacy 2. Effort 3. Critical thinking. 4. Search for help. 5. Peer learning. 6. Academic Integration. 7. Academic self-confidence 8. Discrimination	1. MSLQ 2. Santiago and Einarson Scale. 3. Cooperative Institutional Research Program (CIRP) scale 4. Perceived discrimination scale	1. The lack of academic integration decreased self-efficacy and academic confidence. 2. Academic integration had a positive effect on self-efficacy, which in turn had positive effects on effort and critical thinking.
17	(Hafizah, Norhana, Badariah, & Noorfazila, 2016)	Malaysia	Descriptive n=78	To analyze descriptively and evaluate students' motivation and self-regulated learning in a Circuit Theory course.	Self-regulated learning according to Pintrich's definition	MSLQ	Engineering students have a low level of self-regulated learning.
18	(Zambrano, 2016)	Chile	Mixed: (Descriptive and case study design) n=15	To diagnose, design and implement teaching strategies that facilitate SRL promotion in engineering students.	1. Perceived General Self-Efficacy. 2. Self-regulated learning according to Zimmerman's definition.	Perceived General Self-Efficacy Scale	1. The diagnosis showed that students do not plan or monitor their learning process. 2. Self-regulated learning promotion in the classroom proposal for Software Engineering course.
19	(Gunes, Ozsoy-Gunes, & Kirbaslar, 2015)	Turkey	Causal correlational (explanatory) n=315	Analyze the influence of self-efficacy beliefs on the use of educational internet and self-regulated learning skills for information literacy	1. Self-efficacy beliefs in the use of educational internet. 2. Self-regulated learning skills. 3. Information Literacy	1. Self-efficacy beliefs in the use of educational internet Scale 2. Self-regulated learning skills Scale 3. Information Literacy Scale	The educational use of Internet and self-regulated learning skills are considered effective for information literacy.
20	(Lawanto, Santoso, Lawanto, & Goodridge, 2014)	United States	Correlational n=57	To evaluate students' self-regulated learning (SRL) skills and intensive Web learning environment	Students' self-regulated learning skills in their online learning environment.	Online Self-Regulated Learning Questionnaire (OSLQ)	Higher-performing students significantly outperformed lower-achieving students in: 1. Goal setting. 2. The frequency of access to all course materials. 3. Punctuality of task presentation.
21	(Chi-Tung & Ruey-Gwo, 2011)	China	Explanatory model (Causal correlational) n=188	To build an electrical engineering SRL process model with the basic competences for students that come from technological institutions.	1. Personality traits. 2. Motivation for learning. 3. Action control 4. Learning strategies	1. Mini marker scale to measure personality traits. 2. MSLQ. 3. Action Control Scale. 4. Learning strategies scale.	There are direct effects of student personality, motivation for learning and control of action on self-regulated learning strategies.

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