Regulation of Flipped Learning Activities in Programming: A Systematic Review

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Abstract

Flipped Learning can contribute significantly to learning, however there is an under-utilization of conceptual structures of design in the flipped classroom, with regard to the incorporation of pedagogical methods to promote the activities to be performed by students. The pedagogical design of flipped classrooms needs to provide a model that details how to facilitate activities before, during and after classes. It is important to analyze the moment before the classroom, which involves self-regulation, during the classroom which involves processes related to interaction and collaboration and after the classroom, related to reflective processes. Developing and conducting a systematic review can contribute to an analysis of the current state of research on teacher facilitation in relation to student regulation in flipped learning related to teaching programming. The systematic review was carried out to identify all the research available on self-regulation and co-regulation by students during flipped learning in programming courses. The objective of this research is to identify and analyze relevant research related to the regulation and co-regulation of flipped learning activities in the teaching of programming, and to understand how the self-regulation and co-regulation of students has been approached to engage in activities before the classroom. class, collaboration and problem solving during classes and reflections after class. After a analysis of the articles listed by the systematic review, important gaps in the literature can be observed, such as the lack of approach to the three phases of flipped learning, regulation and co-regulation and all dimensions of regulation. Nor is there a theoretical framework based on processes and strategies of self and co-regulation for teaching computer programming. Thus, the present systematic review has significant relevance and highlights the need for studies that involve all elements of flipped learning in the teaching of programming.

Keywords: regulation; flipped learning; systematic review; programming.

1. Introduction

The flipped learning was used in higher education to support the student-centered learning model (koh, 2019), being a pedagogical method, which involves active learning, collaborative learning and combines online activities and classroom activities (Bergmann & Sams, 2012). Flipped learning encompasses a change in pedagogical strategy, in which students prepare for classes by accessing content in advance,

engaging in activities and solving problems collaboratively during class (Akçayir and Akçayir, 2018) and reflect on learning after class.

Before the classroom, the flipped classroom model reverses the logic of classroom organization. (Setren and Greenberg, 2019). Students generally need to watch online videos assigned by the teacher before class, which is dedicated to conducting group activities proposed by the teacher (O'Flaherty and Phillips, 2015). In addition, students should reflect on the activities performed, as well as their performance after classes.

The flipped classroom model has been shown to be more effective in relation to teacher-centered teaching (Zamorano, Sánchez and Caballero, 2019). However, there are challenges and problems that need to be overcome to help the teacher structure flipped classes (Lundin et al., 2018; O'Flaherty & Phillips, 2015).

It is observed that there is an underutilization of conceptual structures and design in the flipped classroom (O'Flaherty and Phillips, 2015), regarding the incorporation of pedagogical methods to promote the activities to be performed by students. The pedagogical design of flipped classrooms has been widely criticized for not having a theoretical model providing details of how activities would be facilitated before, during and after classes (Brewer and Houligh, 2018).

Studies carried out point to the importance of using appropriate learning strategies (Ye, Chang and Lai, 2018; Lin, 2019), so that students' learning performance meets the expectations of flipped learning activities, before, during and after the classroom of class.

Before the classroom, students need follow-up, to be motivated and instigated to actively engage in the content provided by the teacher, this means that the teacher must know how to mediate students to lead students to productive engagement. However, there are intrinsic difficulties in the planning of activities, such as permeating the understanding of the objective of the tasks, which have a profound effect on the resolution and performance of students, when carrying out activities in a collaborative way, the mediation of the teacher is crucial so that everything is done correctly (Hadwin, Bakhtiar and Miller, 2018).

During the classroom, the online or in-person environments available for students to perform activities may not be adequate and involvement may not be sufficient. To minimize these scenarios, teacher mediation is essential, for that the teacher can use collaboration scripts with specific objectives or other techniques to promote the joint construction of knowledge (Heimbuch, Ollesch and Bodemer, 2018). However, the application of strategies to facilitate collaboration to mediate activities involves complex collaborative processes that may differ depending on the contextual factors in which the teacher may not have prior knowledge. Thus, teachers may not be prepared to mediate and propose activities that evoke productive interactions, which culminated in the joint construction of knowledge.

After the classroom, students must enter into reflective processes (Chen, Hwang and Chang, 2019). Reflective processes involve cognitive aspects, which are higher-order thinking skills, which contribute to the acquisition of complex knowledge. The processes proposed by the teacher can awaken these skills and encourage students to enter a deep reflective process, which helps to promote new knowledge (Naykki, Tarhonen and Hakkinen, 2017). Next, the justification for the systematic review will be discussed.

On the other hand, the flipped classroom model introduces new demands for the teacher. For example, students need specific techniques, mediation by teachers to collaborate (AlJarrah, Thomas and Shehab,

2018). It is desirable that the teacher regulate the activities to organize interactive experiences that support students before, stimulating their motivation, during the collaborative process, and after the inverted classes, a reflexive process (Karakas, Manisaligil and Sarigollu, 2015).

In addition, it is more difficult for the teacher to devise a strategy to apply the flipped classroom, given the lack of theoretical-pedagogical support in the flipped classroom model to avoid the student's procrastination and promote his motivation before classes, promote fruitful interactions during classes and boost reflections after classes (Ye, Chang and Lai, 2018). In an analogy it is like a blank page that intimidates an author who fights against the block to write. This can be intimidating for teachers, who are already used to the traditional model of classes (Rajaram, 2019).

Although flipped learning has been confirmed as an effective strategy for using class time and cultivating students' in-depth thinking and learning, Strayer (2012) still indicated that adopting flipped learning mode without adequate strategic guidance can lead to frustration among students. students in class.

Luo et al. (2020) point out models that incorporate facilitation of flipped classroom student activities, but the problem is that these models are not detailed, actionable or sufficiently specific for each subject. For example, Kim, Kim, Khera and Getman (2014) argue that some pedagogical models of flipped classroom "facilitate the construction of a learning community" (p. 45) without answering "how to build the learning community" or "how to facilitate the process"; Lo and Hew (2017) emphasize the importance of solving problems, however, they do not specify how to design the steps of their solution; Lee, Lim and Kim (2017) highlight the need for a "procedural organization" (p. 440), but there is a lack of explanation on how to achieve it in the pedagogical model of the flipped classroom.

When it comes to a specific context, the principles are even more ambiguous, making implementation difficult in practice. It is true that the flipped classroom is a generic approach that can be customized for any subject area; however, for teachers who are not necessarily familiar with this pedagogical approach, a process design ready to implement will be much more favored. There is a demand to expand the theoretical model in the sense of how to mediate inverted classroom activities (Lobczowski, 2020; Jenkins et.al, 2017; Lin, 2019).

Previous work done incorporated for the development of the flipped classroom approach, but there is still a demand for detailed and specific process projects, given a given theme, to complement the existing knowledge on the regulation of activities to be performed by students (Luo et al., 2020). There is a gap regarding the facilitation of activities before, during and after the specific classroom for a particular subject, as approaches tend to be generic (DeLozier and Rhodes, 2017).

When the topic to be addressed in the flipped classroom is computer programming, addressing inverted learning in programming courses can be particularly difficult, as teachers have to teach subjects that educate students with a high degree of abstraction (McCord and Jeldes, 2019), which may become even more important the facilitation of activities by the teacher.

Amira et al (2019) draw attention to the lack of instructional design framework to be used in planning the general flipped classroom approach to programming, despite considering the flipped classroom as an efficient way to teach programming, when compared to the traditional model. They argue that the content covered in programming classes is dense and, for many students, difficult to understand at the speed that teachers present the concepts. Thus, homework, as part of the flipped classroom format, consisting of

learning new material by watching video lessons and doing exercises and solving problems, can be used successfully as long as there is facilitation of student activities. Tongkoo et al. (2019) propose to involve students in learning inside and outside the classroom, integrating collaborative learning methods with the flipped classroom to cultivate the learning performance of programming in higher education.

In summary, some research provides teachers with possibilities for implementing the flipped classroom in programming courses (Chiang, 2017; McCord and Jeldes, 2019; Herala et.al, 2015; Rosiene and Rosiene, 2015). Among them, there are initiatives to overcome the lack of theorization of the flipped classroom, such as the lack of methods to avoid procrastination and lack of commitment to problem solving in the field of computer programming (AlJarrah et al., 2018), seeking to circumvent the lack of adequate educational support to support students when they participate in programming learning in the flipped classroom. Thus, given the problem of the need for more guidelines in the application of the flipped classroom mentioned above and the existence of works that address this problem in the context of programming, the objective of this systematic review is to reveal in the literature how to facilitate activities for promoting motivation and bypassing procrastination, stimulating engagement during collaborations and resolution and encouraging student self-reflection in flipped learning have been addressed in the context of programming, highlighting possible gaps in the literature.

2. Related Works

There is research in the literature that addresses the problem of mediation of students' activities in the flipped classroom, addressing teaching strategies for facilitating self and co-regulation of students, thus contributing to a better detail of how the flipped classroom can be architected. Below we will exemplify some research in this scenario.

The study by Chen and Chang (2017) investigated the participants' cognitive presence and learning performance. Online discourse analysis was used to explore cognitive presence and students' level of learning was also analyzed. This study explored the students' cognitive presence and learning achievements, integrating the SOP2 Model in which self-study (S), online group execution (O) and dual stage presentations (P2) were implemented in the classroom. flipped class. The integration of the SOP2 model in the inverted classroom was treated as an independent variable, which was investigated in three research questions. The first research question investigated the four categories of cognitive presence, which consist of triggering events, exploration, integration and resolution (Garrison & Anderson, 2003), the second explored individual learning achievements, while the third explored the relationship between cognitive presence and group learning achievements. The research showed satisfactory results during the flipped classroom, however, a post-class analysis was not carried out, which involved reflection processes in relation to flipped learning.

The research by Dooly and Sadler (2020), presents a pedagogical project for teacher training that combines flipped materials, in the classroom and telecollaboration, and a virtual exchange of information between teachers for the training of foreign language teachers. The context of the study involves a course on language learning for future teachers, in which the concept of an inverted classroom was designed for collaborative teacher training with the inclusion of digital tools (Dooly and Sadler, 2020).

The proposal integrates dialogical notions of learning supported by groups carefully organized in dialogic spaces, both in the classroom and online, to generate what they called “learning microgenesis” which is a diachronic, socially situated, contextualized learning process, in the classroom and online, students and teachers became involved in the flipped classroom and understanding was shared by participants in an intersubjective way by everyone to promote learning. The models adopted aim to promote the students' transformative reflection (Naidoo and Kirch, 2016), which is a form of active learning in which students work collaboratively to present and solve problems that arise. The work presents a complex approach with satisfactory results for flipped learning, focused on the development of the student supported by the teacher in dialogical spaces. The main teaching approaches were symbiotic, as each structure reinforced the other through reception, discussion and reflection as a means of helping the student, in this case the teacher's reflection. The results were successful and help to carry out an in-depth analysis of the learning process as knowledge is developed in collaboration between participants (Dooly and Sadler, 2020).

The research by Okmen and Kilic (2020), presents a study to investigate students' performance in relation to self-regulation skills in flipped learning. The study context involves a flipped learning model structured in layers. In the flipped learning model, it adopts a student-centered approach divided into three layers, layer a, b and c., Aiming to develop skills such as selection, responsibility and high-level thinking, respectively (Okmen and Kiliç, 2020). The proposal includes self-regulation, a form for analyzing activities, group analysis and a self-assessment form. The adopted models aim to promote the elaboration of a strategy that involves time, arrangement, and management of self-regulation. The work presented satisfactory results for flipped learning. The main teaching approaches were focused on self-regulation and positive changes were observed at the end of the school semester. The changes promoted were significant as a driving force to create and expand opportunities for carrying out extra activities.

Luo, O'Steen and Brown (2020), promote design through processes for flipped classes, which focus mainly on feedback from colleagues. The design developed for the use of processes is focused on empathy, collaboration, and experimentation, it is structured in the model of design thinking proposed by Plattner et al. (2009), which contains six steps: understand, analyze, analyze the point of view, idealize, prototype and test. In summary, the work makes important contributions to the development of the flipped classroom approach.

Rajaram's research (2019) presents an analysis, an attribution that despite the countless benefits of using the flipped classroom, for instructors unfamiliar with the format, there may be discomfort and ambiguity when they intend to structure and organize a flipped classroom with activities relevant. Flipped learning can help improve secondary education, but organizing and structuring classes in an flipped format is not a simple matter. The work proposes a structure that can help teachers facilitate the development of a structured and systematic approach to courses that involve flipped learning. The structure is based on a learning support system for "e-scaffolding" that can be used in the classroom. Such actions involve understanding online learning in the pre-class period and face-to-face activities in order to help students engage in learning through activities related to collaborative learning. The study showed positive results with the use of collaborative learning and the encouragement of critical thinking. The work presents results that indicated that the learning experience was positive, the students' feedback indicated that they liked to

be involved in flipped learning. The results also point out that flipped learning, through "e-scaffolding", allowed for greater reasoning, which provided a better understanding of the topics covered in the course, improving student performance (Rajaram, 2019).

Sletten's research (2017) presents a work that hypothesizes that the effectiveness of the flipped learning model depends on the interest, involvement, and ability of students to adopt a self-directed learning style. The work aims to examine the relationship between two variables, students 'perceptions of flipped learning and students' behavior in a self-regulated learning model. The aim is to analyze the impact of these variables on the performance of classes involved in the flipped classroom. Such actions involved a case study, structured in an introductory course composed of seventy-six students who used the self-regulated learning strategy. The study showed results that indicate that students' perceptions about flipped learning positively predict the use of strategies for self-regulation. However, the data analyzed did not indicate a relationship between perception and performance. The results obtained suggest that students need to practice self-regulation skills in order to be more effective in teaching, videos sent in pre-class play an essential role for flipped classes, however they require more commitment from students.

Jenkins et al., (2017) presents a study that proposes pedagogical strategies that promote active learning in flipped approaches. It also involves improved practices of an educational design structured in flipped learning supported by information and communication technologies in teaching. The work aims to offer contributions, organizing flipped learning in a pedagogical structure associated with a higher-level approach. The aim is to propose an exploratory approach to provide a guide for educators to map their teaching practices and fit them into instances of flipped learning. Such actions involve flipped learning approaches to propose a tool for critical reflection of existing approaches and course designs, providing the educator with the possibility to design their own version of the flipped classroom that is pedagogically sound and suitable for teaching purposes. The regulation facilitation method proposed in the survey showed satisfactory initial results. The results obtained indicate that the strategies used help to improve teaching and learning.

The research by Zheng et al., (2020) presents a study that aims to show that collaborative learning in the flipped classroom is not a merely collective activity, it includes systematic and discrete actions. Such actions involve self-regulation skills of students studied of themes. The context of the study investigates that, from a theoretical point of view, contradictions related to activities are found, such as contradictions involving themes, tools, platforms, rules and interaction in the community and how these contradictions influence students' understanding. The contradictions involve, for example, contradictions about the content covered, which can lead students to doubt or to a creative block that need to be resolved in order to obtain relevant results. Student engagement can be fostered with solutions that resolve possible contradictions, such as proposing activities that relate topics that can be discussed in groups by students on online platforms, aiming at improvements in planning and applying solutions for the proposed activities.

The exemplified works present promising frameworks, strategies and designs for mediating regulation in flipped learning, proposing solutions that contribute to facilitating the regulation of flipped classes by teachers. However, the vast majority of approaches found in the literature do not provide solutions for specific topics. The works reported also do not present a framework that concurrently encompasses all three phases involved flipped learning: before, during and after, helping to promote learning at all times in

the inverted classroom. In addition, most of the works found in the current literature do not deal with reflective processes, applicable to the moment after class.

Since there is a need to build frameworks involving processes underlying specific subjects, there is a gap regarding the facilitation of activities before, during and after the specific classroom for content set in a particular domain, the focus of this systematic review is to examine how this problem has been treated in the literature, when the subject in question is computer programming, as well as to point out what remains to be explored regarding the mediation of students' activities during flipped learning.

3. Systematic Review Method

This systematic review was structured in a specific method based on the structure proposed by Kitchenham (2007). A systematic review of the literature is a means of identifying, evaluating, and interpreting all available research relevant to a specific research question, topic area or phenomenon of interest (Kitchenham, 2007). The systematic review will be carried out to identify all the available research on self-regulation and co-regulation by students during flipped learning in programming courses.

3.1 Research Question

To achieve the objective of this research to identify relevant research related to the regulation of flipped learning activities in programming courses, the following research question was elaborated to guide the study.

QP. How has self-regulation and co-regulation of students been approached to engage in activities before the classroom, collaboration and problem-solving during classes and reflections after class, in programming courses, during flipped learning?

3.2 Justification of the Need for Systematic Review

Flipped learning is an innovation in education, as it changes the pedagogical teaching strategy (Bergmann and Sams, 2012), the proposal of flipped learning or flipped classroom, involves active methodologies that can stimulate learning (Lo and Hew, 2017).

This systematic review aims to present an analysis of the current state of research on teacher facilitation of student regulation in flipped learning related to teaching programming.

It is important to analyze flipped learning from the perspective of student performance, however the teacher's strategy for regulation may be fundamental (Jdaitawi, 2019) for student engagement in flipped teaching, as in complex teaching approaches such as those involving programming.

Systematic review can help to verify approaches that have been used by teachers and help to identify gaps in research, which, if addressed, can contribute to the improvement of flipped learning in specific environments (Lo, 2019), such as in teaching programming.

After successive and intense researches, no systematic reviews were found that specifically address strategies for regulating flipped learning activities in teaching programming, which highlights the importance of conducting this systematic review.

3.3 Search Strategy and Databases Used

The present study investigated peer-reviewed academic articles published from 2015 to 2020. All selected researches are original and complete, indexed in the highly relevant databases, Science Direct, Web of Science and Scopus. The research was carried out with the following keywords, flipped learning, flipped classroom, flipped classroom, regulation, self-regulation, collaborative learning, facilitation, reflection, self-efficacy and programming, structured in the following search string, ((“flipped learning ”OR“ flipped classroom ”OR“ flipped classroom ”) AND (“ regulation ”OR" self-regulation "OR“ collaborative learning ”OR“ facilitation ”OR" reflection "OR" self-efficacy ") AND (“ programming ”)) as noted in table 1.

Table 1 - Systematic Review Method

1. Data Base	1. Search Strings
1. Science Direct; 2. Web of Science; 3. Scopus.	((“flipped learning” OR “flipped classroom” OR “inverted classroom”) AND (“regulation” OR "self-regulation" OR “collaborative learning” OR “facilitation” OR "reflection" OR "self-efficacy") AND (“programming”))

Next, the inclusion and exclusion criteria of the systematic review will be addressed.

3.4 Inclusion and Exclusion Criteria

To refine the results, the inclusion and exclusion criteria listed in Table 2 were used.

Table 2 - Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
a. Articles that focus on flipped learning and teaching programming; b. Complete research articles; c. Complete review articles; d. Computer Science and Programming articles; e. Complete studies; f. All studies must be in Portuguese or English; g. Research published since 2015. h. Flipped learning must be the central axis of the article, and must be related to teacher facilitation in teaching programming.	a. Book chapter reviews; b. Articles that are not in English or Portuguese; c. Duplicate searches; d. Works that are not relevant to answer the research question.

3.5. Conduct of Research

To organize the research, the Parsifal software (Parsifal, 2018) was used, based on the guidelines for preparing systematic reviews proposed by Kitchenham (2007) or Mendeley (Elsevier, 2020) to organize the references and the PRISMA protocol, to display the results of the systematic review research (Moher, Liberati, Tetzlaff, & Altman, 2009).

3.6 Results

Twenty-three articles were found in the Scopus database with the following search string, TITLE-ABS-KEY ((((("inverted learning" OR "inverted classroom") AND ("regulation" OR "self-regulation" OR "collaborative learning" OR "facilitation" OR "reflection" OR "self-efficacy") AND (" programming"))).

In the ScienceDirect database, 772 articles were found with the following search string, (“inverted learning” OR “inverted classroom”) AND (“regulation” OR “self-regulation” OR “collaborative learning” OR “facilitation” OR "reflection" OR "self-efficacy") AND ("programming").

In the Web of Science database, 18 articles were found with the following search string, ("flipped learning" OR "flipped classroom") AND ("regulation" OR "self-regulation" OR "collaborative learning" OR "facilitation" OR "reflection" OR "self-efficacy") AND ("programming").

In total, 813 articles were found with the search string applied in the three databases.

The study was structured in the PRISMA flow diagram, which contains a set of items based on evidence to structure systematic reviews (Liberati, 2009).

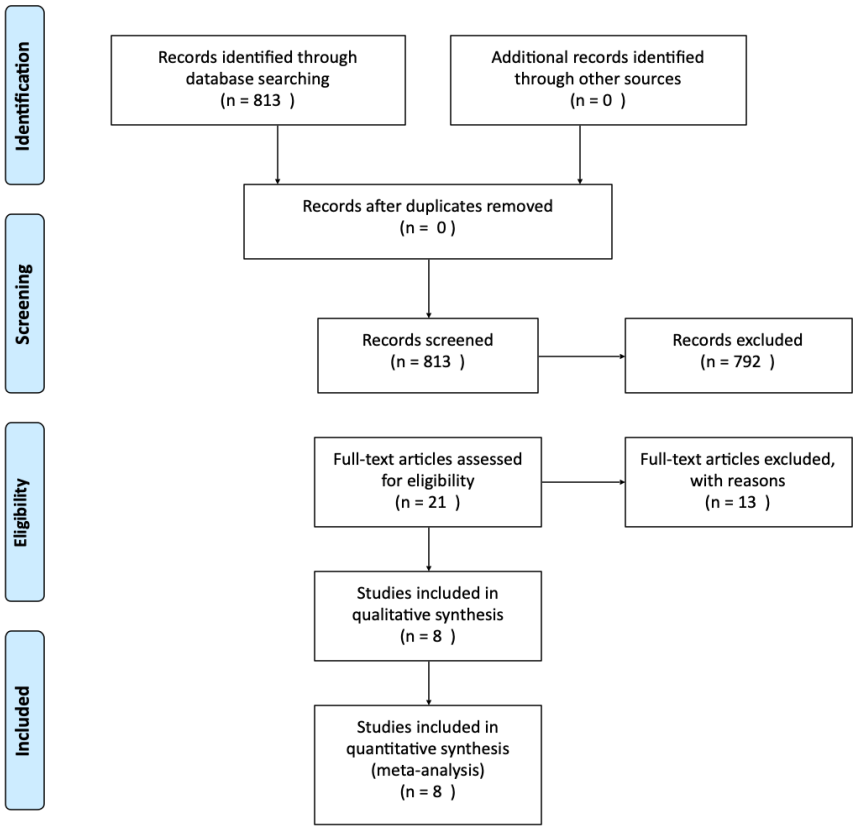

Figure 1 - PRISMA Diagram

Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009).

In the screening stage, after applying the inclusion criteria, Complete research articles; Complete review articles; Computer Science and Programming articles; Complete studies; All studies must be in Portuguese or English. After applying the exclusion criteria: Book chapter reviews; Articles that are not in English or Portuguese; Duplicate searches. After applying the inclusion and exclusion criteria, the number of articles was 21. One article from Scopus database, 11 articles from ScienceDirect and 9 articles from Web of Science. 792 articles were removed for not meeting the inclusion criteria.

In the eligibility stage, the article entitled Investigating the effectiveness of the Flipped Classroom in an introductory Programming Course (Manoj and Paul, 2015) was excluded for presenting a flipped classroom approach focused only on the inversion of the classroom, not treating regulation / mediation and / or co-regulation.

The articles cited below have investigated flipped learning, in the before, during and after learning, however they are not related to flipped learning related to teaching programming, so they were also removed. Are they:

Enhanced Learning Experience by Comparative Investigation of Pedagogical Approach: Flipped Classroom (Shraddha, 2020); Exploring the role of e-learning readiness on student satisfaction and motivation in flipped classroom (Yilmaz, 2017); Impacts of a flipped classroom with a smart learning diagnosis system on students' learning performance, perception, and problem solving ability in a software engineering course (Lin, 2019); Implementing flipped classroom using digital media: A comparison of two demographically different groups perceptions (Sohrabi and Iraj, 2016); Middle school students' flipped learning readiness in foreign language classrooms: Exploring its relationship with personal characteristics and individual circumstances (Hao, 2016); Project-based learning in out-of-class activities: flipped learning based on communities created in real and virtual spaces based on communities created in real and virtual spaces (Yamashita and Yasueda, 2017); Redefining Quality in Engineering Education through the Flipped Classroom Model (Bhat, 2020); Teaching in flipped classrooms: Exploring pre-service teachers' concerns (Hao and Lee, 2016); Micro flip teaching – An innovative model to promote the active involvement of students (Blanco, 2017); Supporting goal setting in flipped classes (Schwarzenberg and Navón, 2020). After the eligibility stage, 13 articles were excluded, and 8 articles were added. The following topic will discuss the results of the selected articles.

3.6.1 Answering the research question

Table 3 involves an analysis of the selected articles in relation to the application of inverted learning, before, during and after the classroom in teaching programming, highlighting which phase of the regulation of flipped learning is being addressed in each article.

Table 3: Regulation before, during and after the Flipped classroom

Article	**Flipped Learning Phases**		
	Before	**During**	**After**

Flipped Classroom with Problem Based Activities: Exploring Self-regulated Learning in a Programming Language Course (Çakıroğlu and Öztürk, 2017)	**Yes**	**No**	**Yes**
Modeling Different Variables in Learning Basic Concepts of Programming in Flipped Classrooms (Durak, 2020)	**Yes**	**Yes**	**No**
Flipped learning readiness in teaching programming in middle schools: Modelling its relation to various variables (Durak, 2018)	**Yes**	**Yes**	**No**
Collaborative Learning in Computer Programming Courses That Adopted The Flipped Classroom (Hayashi, 2015)	**Yes**	**Yes**	**Yes**
Impact of Applying WebGL Technology to Develop an Web Digital Game-based Learning System for Computer Programming Course in Flipped Classroom (Hsu and Lin, 2016)	**Yes**	**Yes**	**Yes**
Analyzing the effects of adapted flipped classroom approach on computer programming success, attitude toward programming, and programming self-efficacy (Ozyurt and Ozyurt, 2018)	**Yes**	**Yes**	**No**
Integrating inquiry learning and knowledge management into a flipped classroom to improve students' web programming performance in higher education (Thonkgoo, 2019)	**Yes**	**Yes**	**Yes**
Flipping and Blending—An Action Research Project on Improving Functional Programming Course (Isomöttönen and Tirronen, 2016)	**Yes**	**Yes**	**No**

Table 4 classifies the articles, showing whether the article deals with self-regulation and co-regulation.

Self-regulated learning refers to the ability and responsibility of students to understand and control their own learning environment, which involves skills such as goal setting, self-monitoring, self-instruction and self-reinforcement (Schraw, Crippen and Hartley, 2006).

Co-regulated learning is the process through which students interact and share the responsibilities of directing various aspects of learning, involving discourses among students that promote positive affect, interaction and cohesion. As an example of a teaching strategy to motivate student co-regulation, a teacher who is teaching an activity on programming may demand that each student research all available data on programming languages and then designate that students discuss the main points found (Pedrosa, 2019; Chan, 2012).

Table 4: Self-regulation e Co-regulation

Article	**Self-regulation**	**Co-regulation**
Flipped Classroom with Problem Based Activities: Exploring Self-regulated Learning in a Programming Language Course (Çakıroğlu and Öztürk, 2017)	**Yes**	**No**
Modeling Different Variables in Learning Basic Concepts of Programming in Flipped Classrooms (Durak, 2020)	**Yes**	**Yes**
Flipped learning readiness in teaching programming in middle schools: Modelling its relation to various variables (Durak, 2018)	**Yes**	**Yes**
Collaborative Learning in Computer Programming Courses That Adopted The Flipped Classroom (Hayashi, 2015)	**Yes**	**Yes**
Impact of Applying WebGL Technology to Develop an Web Digital Game-based Learning System for Computer Programming Course in Flipped Classroom (Hsu and Lin, 2016)	**Yes**	**No**
Analyzing the effects of adapted flipped classroom approach on computer programming success, attitude toward programming, and programming self-efficacy (Ozyurt and Ozyurt, 2018)	**Yes**	**Yes**
Integrating inquiry learning and knowledge management into a flipped classroom to improve students' web programming performance in higher education (Thonkgoo, 2019)	**Yes**	**No**
Flipping and Blending—An Action Research Project on Improving Functional Programming Course (Isomöttönen and Tirronen, 2016)	**Yes**	**No**

According to Kim et al. (2014), self-regulation and co-regulation strategies organize thoughts, emotions, motivations and behaviors. Pintrich (2000) points out four areas of regulation, which are cognition, motivation / affection, behavior and context. The cognitive area concerns the different cognitive strategies that students can use to learn and perform a task, as well as the metacognitive strategies that students can use to control and regulate their cognition. The area of motivation and affection concerns the various motivational beliefs that students may have about themselves in relation to the task, such as beliefs of self-efficacy and values for the task. The area of behavior reflects the general effort that the individual

can exert on the task, as well as persistence, seeking help and choosing behaviors. The fourth area, context, represents various aspects of the task environment or general classroom or cultural context where learning is taking place. Table 5 presents a classification of the articles, according to the regulation area covered.

Table 5: Table showing the regulation dimensions covered in the works.

Article	**Regulation areas**			
	Cognition	**Motivation/ affection**	**Behavior**	**Context**
Flipped Classroom with Problem Based Activities: Exploring Self-regulated Learning in a Programming Language Course (Çakıroğlu and Öztürk, 2017)	**Yes**	**Yes**	**Yes**	**No**
Modeling Different Variables in Learning Basic Concepts of Programming in Flipped Classrooms (Durak, 2020)	**Yes**	**Yes**	**No**	**No**
Flipped learning readiness in teaching programming in middle schools: Modelling its relation to various variables (Durak, 2018)	**Yes**	**Yes**	**Yes**	**No**
Collaborative Learning in Computer Programming Courses That Adopted The Flipped Classroom (Hayashi, 2015)	**Yes**	**Yes**	**No**	**No**
Analyzing the effects of adapted flipped classroom approach on computer programming success, attitude toward programming, and programming self-efficacy (Ozyurt and Ozyurt, 2018)	**Yes**	**Yes**	**No**	**No**
Integrating inquiry learning and knowledge management into a flipped classroom to improve students' web programming performance in higher education (Thonkgoo, 2019)	**Yes**	**Yes**	**No**	**Yes**
Flipping and Blending—An Action Research Project on Improving Functional Programming Course (Isomöttönen and Tirronen, 2016)	**Yes**	**Yes**	**No**	**Yes**
Analyzing the effects of adapted flipped classroom approach on computer programming success, attitude toward programming, and programming self-efficacy (Ozyurt and Ozyurt, 2018)	**Yes**	**Yes**	**No**	**No**

The article entitled, "Flipped Classroom with Problem Based Activities: Exploring Self-regulated Learning in a Programming Language Course (Çakıroğlu and Öztürk, 2017)" ', deals with flipped learning, before, outside the classroom, however, despite citing activities during the classroom, there is no specific analysis related to the development of this learning phase, focusing exclusively on activities carried out before the classroom that require the use of self-regulation. Self-regulation is generally considered from

the point of revealing students' control skills over what, when and how to study. Reflective aspects related to after the classroom are also analyzed in the article. This study explores the self-regulation skills that students developed in flipped learning, in which problem-based activities were used. The guiding research question of the work involves studying the extent to which students have developed self-regulation skills in the flipped classroom with problem-based learning. To assess self-regulation, the article is based on studies that address cognitive, metacognitive and self-regulatory strategies. However, co-regulation is not addressed because there was no application in the study that involved an accurate analysis of co-regulation and how it could have influenced the results presented by the article. The dimensions of cognition, motivation and behavior are analyzed, which are based on self-regulation activities structured in problem solving, in which students develop the skills to manage what, when and how to study.

The article entitled, "Modeling Different Variables in Learning Basic Concepts of Programming in Flipped Classrooms (Durak, 2020)" ', deals with flipped learning, before, outside the classroom and during, in the classroom, however it does not analyze reflective aspects related after the classroom.

The study is organized from a conceptual framework, which structures activities outside the classroom and during the classroom. The framework is structured as follows, outside the classroom there are 5 stages of activities that involve, presentation of the course, reading of specific materials, online discussion in working groups, tasks related to programming, videos and a work project. In the classroom, there are 4 steps that involve the presentation of the work project, the use of AppInventor for work group activities, programming exercises and the final presentations. The article presents an investigation related to the viability of the flipped classroom model applied to programming training. The study involves an analysis about the perspective of self-regulation and also deals with co-regulation, in which groups are structured so that students interact and share the responsibilities of conducting the interaction, involving speeches among students that promote motivation. To assess self-regulation, the article is based on studies that address strategies related to the development of cognition and motivation / affect, however there is no specialized analysis related to behavior and context.

The article entitled, "Flipped learning readiness in teaching programming in middle schools: Modeling its relation to various variables (Durak, 2018)", deals with flipped learning, before, outside the classroom and during, in the classroom, however, not analyzes reflective aspects related to after the classroom. The article involves self-regulation and co-regulation. The article presents in a theoretical framework, the flipped classroom model and the flipped classroom model applied to teaching programming. The study investigates the learning processes related to self-efficacy, self-regulation and also deals with co-regulation with respect to regulatory strategies used to foster interaction and collaboration between students. A learning control related to self-direction, engagement, attitude and behavior in relation to self-regulation and self-regulation effectiveness in flipped learning applied to programming is done. It also involves an analysis of the interaction by co-regulation strategies that are presented in the method proposed by the article. The article covers cognition, motivation, behavior, however there is no specialized analysis in relation to the context.

The article entitled, "Collaborative Learning in Computer Programming Courses That Adopted the Flipped Classroom (Hayashi, 2015)" ', deals with flipped learning before, outside the classroom, during, in the classroom, and analyzes reflective aspects related to after the classroom. Self-regulation is also used in

order to promote the motivation and learning of each student in the programming courses. The article brings a combination of the flipped classroom and collaborative learning with the main objective of spending most of the time in a programming class with collaboration between students. To measure the reflective processes, the constant application of online tests was used to clarify the reasons why students understood or did not understand the contents worked on. Co-regulation is approached from the point of view of keeping students in constant group collaboration, contributing with each other to conduct flipped activities. The article deals with cognition and motivation, however there is no analysis related to behavior and context.

The article entitled, "Impact of the Application of WebGL Technology on the Development of a Learning System based on Digital Web Games for the Computer Programming Course in inverted Room (Hsu and Lin, 2016)" ', proposes the use of an online system flipped learning to promote students' interest and motivation to learn programming and improve performance. For this purpose, a structure based on the flipped classroom design by Bergmann and Sams (2012) was formulated, in order to encourage students to develop autonomy and cooperation in learning. The article deals with rules related to automatic regulation; however, it does not specifically address co-regulation. The dimensions of cognition and motivation are investigated in the article, although elements related to behavior are indirectly cited, there was no detailed analysis of this dimension, the context was also not investigated.

The article entitled, "Integrating investigative learning and knowledge management in an flipped classroom to improve student performance in web programming in higher education (Thonkgoo, 2019)" ', deals with flipped learning, before, outside the classroom classroom, during, in the classroom , and analyzes reflective aspects related to after the classroom. It is also about using self-regulation that aims to stimulate communication and the construction of students' knowledge, however co-regulation is not addressed because there was no application in the study that involved an accurate analysis of co-regulation and how it could have influenced students. results presented by the article. The study proposed to integrate an inverted classroom into a K-12, high school class, to promote students' online programming learning performance in a higher education environment. Despite elements related to co-regulation indirectly commented, there is no study about co-regulation in the teaching and learning proposal. The article deals with cognition, verifying the impact related to learning, motivation, however the behavior is not verified, but a proposal to investigate the context when making a contextual analysis in the inversion of the learning environment.

The article entitled, "Flipping and Blending - An Action Research Project on the Functional Programming Improvement Course (Isomöttönen and Tirronen, 2016)" ', aims to research and provide means to improve the teaching of programming in an environment of practical and flexible study, correlating flipped and combined learning. The article analyzes a need to seek to program, proposes a flexible method for an flipped classroom application, in order to promote group work and improve understanding, to facilitate the application of concepts related to programming, the article also exposes problems related to flexibility in the use of flipped and blended learning. The article presents flipped learning, through automatic regulation, not that it tends to provide means for the students to mediate as their own activities, it does not cover co-regulation and how it could have influenced the results obtained. The article addresses flipped learning from the perspective of before and during but does not analyze

reflective aspects related to after the classroom. The article deals with cognition, metacognition, motivation, context and cites behavior as an item to be investigated in future research.

The article entitled, "Analyzing the effects of the adapted flipped classroom approach on the success of computer programming, attitude towards programming and self-efficacy of programming (Ozyurt and Ozyurt, 2018)" presents the flipped classroom and the learning of programming, it is guided by the analysis about computer programming, an automatic execution of programming and as group activities in relation to programming, it also investigates whether inverted learning promotes effects that differ from students' previous experiences based on knowledge related to programming. The article addresses self-regularization, in activities that involve automatic execution and co-regulation, when structuring group activities, in which students must help others to carry out the proposed activities. The study was conducted with students from the Introduction to Programming course. They were analyzed as experiences of the activities before and during the classroom. The activities were carried out in groups and the data released were quantitative. An analysis related to the objectives of the proposed method, carried out according to the grades defined by the students. The dimensions of cognition and motivation were analyzed; however, behavior and context were not included in the work.

4. Conclusions and Discussions

Flipped learning is a generic approach that can be implemented in different areas and disciplines, however we can see that it is difficult for teachers to implement flipped learning, as there is the involvement of how the teacher will apply the engagement and structure the activities before, during and after learning, regulation, co-regulation and employing the dimensions of rules in certain specifications, which requires knowledge by the implementing teacher to facilitate the regulation of learning to be carried out by student students.

With regard to programming, the content covered in classes is dense and, for many students, difficult to understand and regulate, it is desirable that the teacher mediate activities to facilitate regulation that support student engagement before, during, and after school. inverted classes, which contributes to the construction of complex knowledge. It is important to help students improve automatic regulation and become involved in regulation. For this, the teacher must design activities in a design that encompasses the dimensions of regulation related to cognition, motivation / affection, behavior and context.

After a detailed analysis of the articles listed by the systematic review, an important gap in the literature can be observed. All articles deal with flipped learning in teaching programming, before and during the classroom, however only 4 articles analyzed reflective processes related to students. Regarding regulation and co-regulation, 4 cover regulation and co-regulation. Regarding the dimensions of regulation, all articles address the dimensions of cognition and motivation, but only 2 address behavior, 20% of the total and only 2 investigate the context, and 20% of the total. The main gap observed is that no investigated article involves the three phases of flipped learning, regulation and co-regulation and all dimensions of regulation. Nor is there a theoretical framework supporting processes and strategies of self and co-regulation for teaching computer programming. Thus, the present systematic review highlights the need for studies that involve all the elements investigated, so that the inverted learning in teaching programming can be used

properly. In view of the results obtained, the systematic review points to a gap in the literature, with regard to how the teacher can promote self and co-regulation of students, to be explored by researchers in the area of information technology and education.

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