An Approach to Co-Design and Self-Regulated Learning in Technological Environments. Systematic Review

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ABSTRACT

Present-day society calls for new student-centred didactic methodologies that make the student an active participant in their learning process. Strategies aimed at training citizens and professionals must adapt and respond to a society that is constantly changing. In this context, self-regulated learning and educational co-design emerge as key concepts in the development of new educational approaches. The present study seeks to identify the elements shared by models of self-regulation and educational co-design in technology-enhanced learning environments. To this end, a systematic review of the scientific literature during the period 2014-2019 has been conducted. The search was carried out using five databases: (1) Ebsco Host; (2) Web of Science; (3) Scopus; (4) ERIC; (5) Dialnet. A total of 830 references and 21 papers meeting the criteria for inclusion were identified. An analysis of the studies selected enabled us to identify the self-regulation models associated with co-design learning processes, as well as the elements they have in common. These include planning, motivation, cognition, task management, collaboration, and degree of success. The results provide the first steps for the construction of a co-design model, which includes guidelines for the creation of personalised learning pathways in technology-enhanced environments.

Keywords SELF-REGULATION OF LEARNING, LEARNING ENVIRONMENTS, ICT, INSTRUCTIONAL DESIGN, STUDENT PARTICIPATION

1 INTRODUCTION

Learning processes demand new strategies to engage with students and their educational needs. Research in this field has been increasing. Recent studies in higher education suggest that the knowledge people need to live, work, and to become competitive professionals in society is interdisciplinary and problem-oriented (Freeman, Becker, Cummins, & Davis, 2017). Similarly, the *OECD Skills Outlook 2019* (2019) points to the importance of using technology as a way of acquiring skills for the 21st century. At the same time, it reiterates the value of tools that help students to personalise and regulate their own learning. This

implies the creation of educational environments that offer solutions to the issues raised by the digital era and the educational community, focusing on aspects that include the learners themselves, their learning processes, and course content (Roschelle, Penuel, & Shechtman, 2006). Based on this perspective, several teaching methodologies and approaches have been developed that stress the importance of the teacher-student relationship as a key factor in educational co-design practices (Bovill, 2020; Kinzie & Kuh, 2017; Kuh, 2008; Magolda & Astin, 1993). Whenever student-centred design is implemented, it is important that the students are the protagonists (Gros, 2019). Thus, the application of co-design techniques to foster participation, collaboration and co-creation between teachers and students at classroom level is essential (Bovill, 2020).

1.1 Co-Designing Learning

The term co-design is a complex one to define, as it draws on a range of perspectives. It refers to the collective creativity of knowledge, to the advancement of the implementation of technological designs that respond to educational needs (Gros, 2019) and to learning processes (Hannon, Danahi, Schneider, Coopey, & Garber, 2012; Leinonen & Durall-Gazulla, 2014; Penuel, 2019; Zheng, 2015). Co-design procedures are linked to participatory and collaborative research methods (Bovill, 2020; Gros, 2019). Their origins lie in the Scandinavian tradition, associated with instructional design, constructivist principles and connectivist theories (Mor & Craft, 2012). For this reason, Kalantzis and Cope (2010) argue that co-design-based strategies represent a shift in instructional practices, in the roles played by participants, and in student decision-making with respect to content. Currently, studies using this methodology are based on the production of learning materials, curriculum development, the creation of a product, or as a training system (Janssen, Könings, & van Merriënboer, 2017; Könings, Seidel, & Merriënboer, 2014; Penuel, 2019). Likewise, Roschelle, et al. (2006, p. 607) state that for co-design to take place, a number of criteria must be met. It needs to: (1) Involve concrete, tangible innovation; (2) Be developed through design-based research, participatory research or formative research; (3) Be flexible and potentially have different iterations; (4) Be the result of a participatory teamwork experience; (5) Respect learning cycles; (6) Include virtual or face-to-face actions to facilitate teamwork; (7) Require the participants in the process to assume responsibility; (8) Use complex data analysis and allow for the introduction of interdisciplinary methods, thus enhancing validity and objectivity.

From an educational point of view, co-design initiatives happen when teachers and students work together collaboratively to create course components and/or pedagogical approaches (Bovill, Cook-Sather, Felten, Millard, & Moore-Cherry, 2016). From a practical point of view, there is no single way of delivering co-design. Different methods and tools exist, although there are similarities between them (Mor, Ferguson, & Wasson, 2015; Pastor, Lozano, & Gros, 2017). In light of these considerations, recent studies show that this type of participation can promote deeper learning among students, as well as provide key insights to guide teacher intervention (Gros, 2019).

1.2 Self-Regulation of Learning

Zimmerman's work (1989) in this field was groundbreaking. His studies describe self-regulated students as those who are in control of their own learning processes, based on metacognitive, motivational and behavioural variables. At the same time, Mccombs (1989) emphasised the active role of students in selecting their own goals, planning strategies and evaluating their own learning performance. Consequently, there are different theoretical models that define self-regulated learning from different perspectives, and among these we should highlight the following:

- Zimmerman's cyclical model, Zimmerman (2000) and Zimmerman and Moylan (2009). Self-regulation is organised around three stages: forethought, performance and self-reflection.

- Bandura (1986, 1997) and Zimmerman (1989, 2008). Self-regulated learning is a socially driven process, one in which the student sets her or his learning objectives, monitoring, regulating and controlling the acquisition of knowledge, being guided by goals and context.

- Boekaerts' Heuristic Model (1995; 1996). This model articulates psychological aspects, including motivation, emotion, metacognition, self-concept and learning. Here, importance is placed on task evaluation by the learner.

- Winne and Hadwin's four-stage model (Winne & Hadwin, 2008). It focuses on the way students' cognitive processing works when planning, developing and evaluating a task.

- The Pintrich model (2000). This is a four-stage model for achieving self-regulation: forethought, monitoring, control and reflection.

Co-design procedures are closely related to self-regulation, in terms of flexibility and the pace of learning. According to Zimmerman (2001), the main cause of student failure is an inability to self-regulate effectively. This assertion is in line with what was recently put forward by the *OECD Skills Outlook 2019* (2019). For years now, various approaches have been taken towards the exploration of student participation in curriculum planning and design. The aim has been to incorporate student views on teaching, and to achieve improvements in a collaborative way (Bain & Zimmerman, 2009).

1.3 Technological Learning Contexts

Technology Enhanced Learning Environments (TELE) refers to contexts that facilitate the acquisition of knowledge and skills with the support of ICT (Steffens et al., 2015). With regard to technology, it is important to distinguish between course-specific resources and applications for group work. In this sense, it is necessary to consider which technological tools can be adapted to the characteristics of these methodologies and to student needs (Gros, 2019). Currently there are few studies that address the issue of technological applications used in co-design processes. Research is needed in this area to analyse what kind of tools can improve teaching-learning processes. However, more evidence has been found

regarding technologies that favour self-regulation, showing that digital technologies have great potential for the development of self-regulation (Marcelo & Rijo, 2019).

Accordingly, the aim of this study was to identify models of self-regulated learning associated with educational co-design in technology-enhanced learning environments. Through a systematic review of the literature, we aim to answer the following questions: Which models of self-regulation are associated with the co-design of learning in TELE?

Which models of co-design are associated with the self-regulation of learning in TELE? How are the relationships between the different agents involved in co-design in TELE established? What kind of technology is used to support the co-design and self-regulation processes?

2 METHODS

Systematic reviews seek to draw together all the knowledge in a specific area, highlighting what is known about a particular topic through the results obtained in different studies, and to provide recommendations regarding future research and practice (Moreno, Muñoz, Cuellar, Domancic, & Villanueva, 2018). As a first step, it is necessary to establish criteria to determine which articles are to be selected as part of the final sample, and which are not. To this end, the principles set out in the PRISMA declaration (Urrútia & Bonfill, 2010) were taken into account. The review process was performed in four stages:

Stage 1. Localisation of the articles. At this stage search criteria were established, and databases chosen: 830 scientific articles in English and Spanish, published between 2014-2019 were identified on the following databases: (1) Ebsco Host; (2) Web of Science; (3) Scopus; (4) ERIC; (5) Dialnet. Being aware that the terminology used to define this concept is extremely diverse, we chose to locate articles that specifically use the terms co-design, self-regulation and technology, thus configuring the following search string: Co-design OR codesign OR co design AND learning AND techno* OR computer AND self-regulation OR self regulation.

Stage 2. Selection and eligibility. The purpose and the context of the research conditions determined the inclusion and exclusion criteria, as shown in Table 1. In order to apply these criteria, records from the databases were imported into the Rayyan QCRI tool, which allows the criteria to be applied collaboratively (Aveyard, 2007). Duplicates were eliminated, and an initial analysis was carried out using the abstracts of the articles. Those that did not meet the inclusion criteria were excluded, which left 197 articles for the next stage.

Stage 3. Analysis of the selected articles. A protocol was developed for the purpose of extracting specific information and establishing a classification system using the Airtable database. The items included in the protocol were: (1) Years; (2) Authors; (3) Title of article; (4) Self-regulation model; (5) Elements; (6) Co-design model; (7) Co-design elements; (8) Agents involved in co-design; (9) Technology; (10) Attached article; (11) Remarks. Once all articles had been analysed, those that did not meet the inclusion criteria were excluded.

Stage 4. Analysis of the articles included. The protocol was applied to the 21 articles selected in order to carry out an in-depth analysis and to extract the relevant information.

Table 1 Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Years published: 2014-2019	Year of publication different from the period from 2014-2019
They involve the use of technology	The theme not related to co-design and self-regulation
Refers to joint co-design actions in learning processes	No use is made of technology
Refer to self-regulatory processes within teaching	The term self-regulation is applied in areas other than teaching.
The work is focused on the educational field, specifically the learning teaching processesTipo de publicación: Artículo	Documents belong to areas other than educational.Tipo de publicación: Artículo
Type of publication: ArticleTipo de publicación: Artículo	Type of publication. Reviews, meta-analysis and doctoral thesesRevisiones y metaanálisis

Figure 1 shows the review process described in the previous section, following the criteria set out in the PRISMA declaration (Urrútia & Bonfill, 2010).
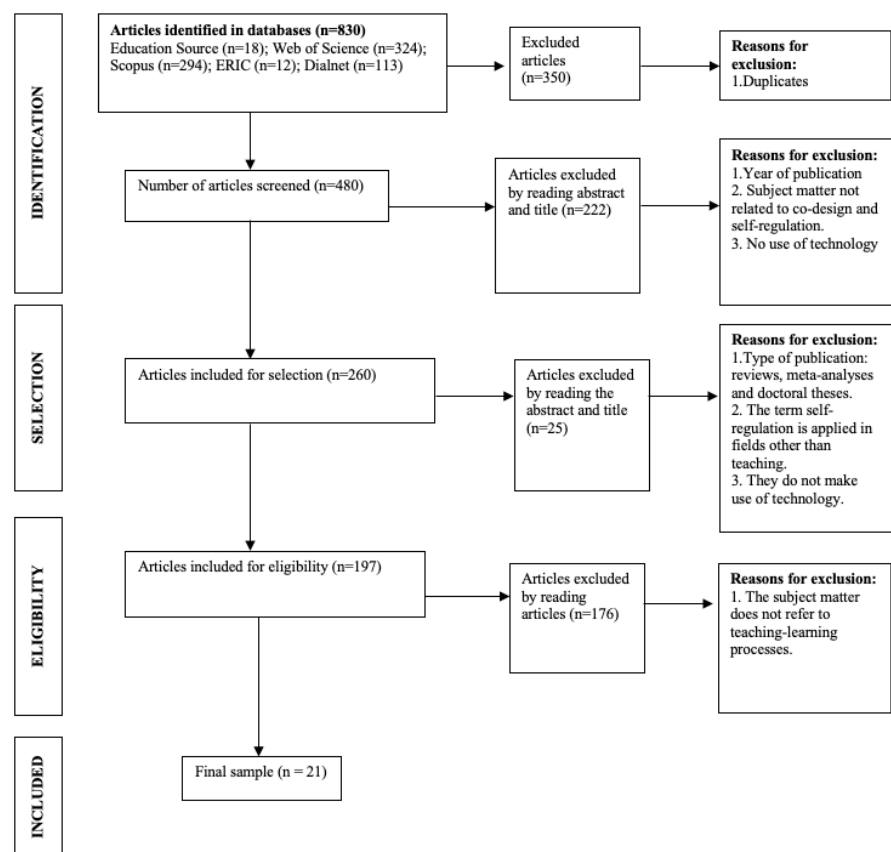
Figure 1 Adaptation of the PRISMA flowchart (Hutton, Catalá-López, & Moher, 2016) showing the different stages involved in this systematic review.

The 21 manuscripts representing the sample selected are presented in chronological order in the form of a table (Table 2). The search took place in December, and some publications from the year 2020 were finally included.

Table 2 Papers analyzed in the systematic review

| Article analyzed	Reference	Type
1	Cortada-Pujol et al. (2014)	Article
2	Cviko et al. (2015)	Article
3	Manso and Llamas (2015)	Article
4	Järvelä (2015)	Article
5	Littlejohn and Milligan (2015)	Article
6	Weitze (2015)	Congress
7	Bovill et al. (2016)	Article
8	González et al. (2016)	Article
9	Zhao (2016)	Article
10	Barbera et al. (2017)	Article
11	Kintu et al. (2017)	Article
12	Zahedi and Heaton (2017)	Article
13	Trischler et al. (2018)	Article
14	Celuch et al. (2018)	Article
15	Garcia et al. (2018)	Article
16	Hyysalo et al. (2019)	Article
17	González-Yebra et al. (2019)	Article
18	Wareing et al. (2019)	Article
19	Higgins et al. (2019)	Article
20	Bovill (2020)	Article
21	Dural et al. (2020)	Article

3 RESULTS

This section presents the results in relation to the research questions posed.

3.1 Self-Regulation Models Associated with the Learning Co-Design Process

The concepts underpinning self-regulation models appear in the theoretical frameworks or in the conclusions of the research analysed. In a single paper, reference is made to one or sometimes to several models of self-regulation. Thus, there are others that mention the contributions made by Zimmerman, although they do not cite a specific model. Moreover, the term self-regulation appears without being linked to any theoretical approach (Figure 2).

Each theoretical contribution proposes certain stages for the achievement of self-regulation, in which a series of elements appear. These are detailed in the papers. The processes and elements of the self-regulation models found in the papers analysed are specified below (Table 3):
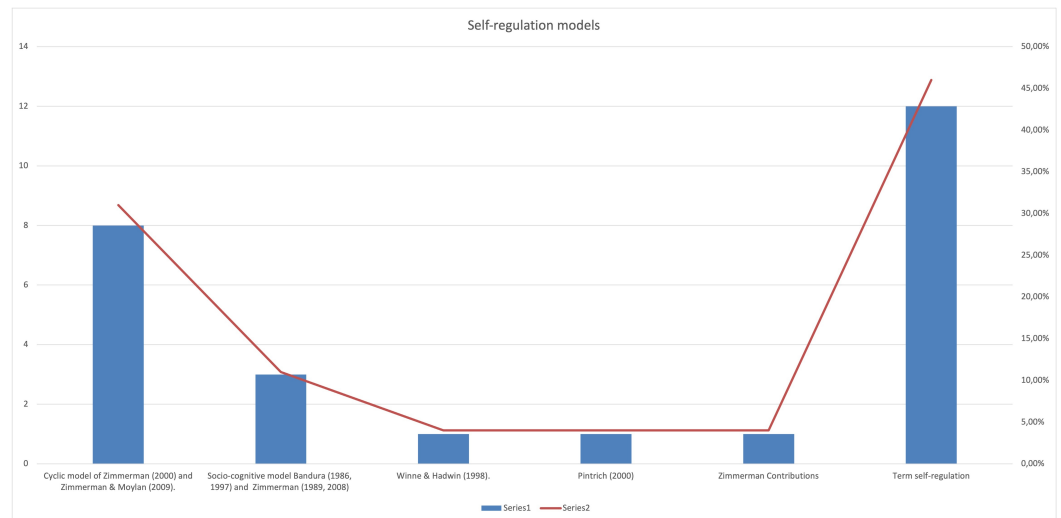
Figure 2 Self-regulation models associated with the co-design of learning process.

The key elements that appear repeatedly in the processes of self-regulation are: Planning (n=17); Motivation (n=8); Organisation (n=6); Evaluation (n=5); Task execution (n=4); Goals (n=3); Cognition (n=3); Learning strategies (n=2). Other factors are mentioned once only. Planning stands out ahead of the rest (n=17). The term is to be understood from the point of view of organisation at the individual level. In other words, the self-regulation process begins with an analysis of the task, broken down into smaller units. Subsequently goals are set, and a personal strategy for how they are to be achieved is established, using prior knowledge as a starting point (Panadero & Alonso-Tapia, 2014; Zimmerman & Moylan, 2009). Furthermore, according to Zimmerman (2008), planning is the self-regulatory process par excellence, as it determines student success. Motivation (n=8) comes in second place, as a crucial concept for task planning and development (Panadero & Alonso-Tapia, 2014) .

3.2 Co-Design Models Associated with the Self-Regulation of the Learning Process

The conceptualisations of co-design analysed refer to a collaborative process of course/curriculum design. The actions developed and the nature of the relationship between their components are what characterise each perspective. The co-design models presented in the papers reviewed and the concepts that underpin them are specified in Table 4:

The model that appears most frequently is collaborative (n=9), followed by participatory (n=5) and service-learning based co-design (n=3). Occasionally, collaborative and participatory models are mentioned in the same research project. Consequently, some authors consider that a rewarding design process needs to include both. In a similar vein, some research points to differences in this respect, specifically in terms of the degree of participant involvement. This implies that sometimes collaborative processes do not involve the

Table 3 Self-regulation models, processes and key elements

Reference models	Learning Self-Regulation Process	Elements
Cyclic model of Zimmerman (2000) and Zimmerman and Moylan (2009)	Planning Reflection Execution	Motivation Self-observation Self control Time management Success Self appraisal Evaluation Beliefs Forecast Attention Reflection Planning"
Pintrich (2000)	Preparation, planning and activation Monitoring Control Process evaluation	Motivation Cognition Success Time management Evaluation
Winne and Hadwin (1998)	Defining tasks Definition of goals and plans Implementation of tactics Metacognition adaptation	Success Goals Planning Cognition Evaluation
Socio-cognitive model Bandura (1986, 1997) and Zimmerman (1989, 2008)	Process planning Definition of the objectives Organization of information Supervision	Self-efficacy Motivation Success Self control Expectations Attention Beliefs Organization Planning Interests objectives Supervision

introduction and discussion of participants' ideas. Actions are reduced to carrying out the assigned task.

However, for participatory design to take place, it is necessary for individuals to actively participate by expressing their opinions and providing input, thus enabling interaction with the group. Studies show a number of elements that appear in the co-design process, which are detailed in Table 5. The most common are collaboration (n=16), motivation (n=10), participation (n=9), planning (n=8) and goal setting (n=7). Other items are mentioned between (n=5) and (n=1) in the documents analysed (Table 5).

3.3 Relationships Between the Different Agents Involved in Co-Design

The partnerships through which co-design actions take place vary depending on the project. Four types of interactions have been observed in the studies reviewed:

Table 4 Co-design models associated with self-regulation

Co-design model	Definition	f	%
Co-design based on participatory design	It aims at collaboration between participants (Bovill, 2020).	5	23%
Co-design based on intermediate design	It describes how the teacher shapes social processes and creates conditions for learning, as well as the phenomenon of the individual learner constantly recreating or redesigning information through his or her own meaning-making processes. It refers to the design of small things to form a larger design.	1	4%
Student voice based co-design	According to Anderson and Shattuck (2012) it is a methodology that has the main characteristic of developing multiple collaborative interactions for the purpose of evaluating, innovating and improving teaching and learning processes. The participation of students requires planning and implementation, to ensure that the final design truly responds to their needs and interests.	1	4%
Service-learning based co-design	Learning design is based on the needs, experience and service to the community targeted by the project to be designed (Yu & Sangiorgi, 2018).	3	14%
Co-design SAP (Students as Partners)	It is a model that involves students and staff (including academic/teaching and professional staff) working together in teaching and learning in higher education. Partnership is a reciprocal process through which all participants have the opportunity to contribute equally, to curricular or pedagogical conceptualisation, decision-making, implementation, research or analysis (Bovill et al., 2016)	2	5%
Co-design based on the Kano approach	The model provides a better understanding of how customers evaluate a product or its offering and helps companies identify those attributes that need to be improved (Rotar & Kozar, 2017).	2	5%
Co-design based on the Collaborative Model	Students work cooperatively within a project, their learning experience is enriched: they better understand the complexity of the design project.	9	41%
Inquiry-based co-design	It is based on questions and the scientific process so that students gain personal experience with scientific enquiry: identifying and asking questions, designing and conducting investigations, analysing evidence, using models and explanations, and communicating results (Abdelraheem & Asan, 2006).	1	4%

Table 5 Elements related to co-design and self-regulation

Co-design elements	f	Co-design elements	f	Co-design elements	f	Co-design elements	f
Collaboration	16	Evaluation	3	Stimulation	1	Responsibility	1
Motivation	10	Feed-back	3	Time planning	1	Dialogue	1
Participation	9	Organization	3	Regulation	1	Co-creation	1
Planning	8	Teamwork	3	Task execution	1	Reflection	1
Objectives	7	Communication	3	Affective aspects of content	1	Structure	1
Needs	5	Interaction	2	Rules	1		
Goals	5	Learning strategies	2	Instructions	1		
Success	4	Adaptability	2	Learning attitudes	1		
Cognition	4	Expectations	1	Support	1		

- Between pupils. Takes place when a group of students carry out a task or work on a project together.
- Between teachers. This implies the participation of all teaching staff in working on tasks or projects with the aim of developing them with the students.
- Teachers and pupils. The interaction between the two groups involves taking decisions on the teaching processes to be followed during a class, an activity or a course.

- Teachers and other professionals. At this level, co-design is achieved by means of contributions from both teachers and external experts on a given subject. Their collaboration generates projects, activities and outcomes for implementation in the classroom.

In the records analysed, level one interactions occurred in 38% (n=8). At level two, interaction between teachers (n=7) 33%. At level three, between pupils and teachers (n=4) 19%. And at level four, between teachers and external experts (n=2) 10%.

3.4 Technology Used to Support the Co-Design and Self-Regulation Processes

The research specifies the use of virtual learning environments to develop co-design and self-regulation actions. Institutional platforms, 3D virtual environments or MOOCs are used. The tools are linked to Zimmerman (2000) and Zimmerman and Moylan (2009) cyclical model of self-regulation, as this is the one most frequently referred to. Thus, each is linked to the stages within this model, and in turn to the co-design models used. The applications used fulfil a series of functions based on the processes of communication, planning and/or organisation, task execution and reflection (Table 6).

Table 6 Classification of technological tools

| Technology	f	Tools	Functions
Institutional platform	7	Infographic	Planning the learning teaching process
		Calendar	Organization and management
		WebQuests	Organization and management. Task execution
		Message forum	Reflection and creation of documents. Communication
		Concept map	Organization and management
		Storyboard	Organization and management
		Videos	Reflection
		Wiki	Reflection and creation of documents. Communication
		Social bookmarks	Task execution
		Computer-supported collaborative learning (CSCL)	Task execution and reflection
		Learning management system (LMS)	Task execution and reflection
		Internet browser	Task execution
		Google Docs	Task execution and reflection
		Questionnaire	Reflection and evaluation
		Email	Communication
MOOCS	1	Calendar	Organization and management
		Chat	Organization and management
Virtual games	1	Infographic	Planning the learning teaching process

4 DISCUSSION AND CONCLUSIONS

On the basis of the review carried out, the publications that address co-design and self-regulation within technological environments are scarce (n=21), which shows that the central focus of these studies is not technology, indicating the need to develop research in this field as pointed out by Gros (2019) , although the subject is beginning to be of interest. On the other hand, one of the objectives was to understand the self-regulation models that are usually associated with educational co-design. In this regard, the results indicate that only 8 cases are linked with a specific model, and that in most cases self-regulation is addressed without an approach having been chosen in advance. The perspectives related to co-design were participatory and collaborative models. These emphasise the importance of participation between students and teachers so that deeper learning can take place (Bovill, 2020). Projects have been co-designed by means of workshops or participatory activities, led and coordinated by teachers or researchers. The conclusions drawn from these kinds of experiences are intended to construct new knowledge that will facilitate dissemination and transfer in order to develop innovative designs. However, Gros (2019) warns that there are limitations to the publication of this type of research in scientific journals. The different studies analysed show that there can be different interactions and levels of co-design, depending on the degree of involvement of all the participants in the process. The following diagram shows the different interactions (Figure 3).

Figure 3 Levels in the co-design of learning.

An analysis of the concepts related to the self-regulation of learning and co-design shows n=12 commonalities between the elements of each variable. At the same time, synchrony is identified between the most frequently reiterated items in the self-regulation and co-design models. Planning and motivation top the number of commonalities (Figure 4).

The acquisition of knowledge by the student is linked to participation, design, planning and motivation. In this case technology provides tools that support the process, although there are no specific studies on this (Gros, 2019). Planning and cognition are directly linked to Zimmerman (2000) cyclical self-regulation model and its subsequent revision by Zimmerman and Moylan (2009). Planning is the quintessential self-regulatory process and is a
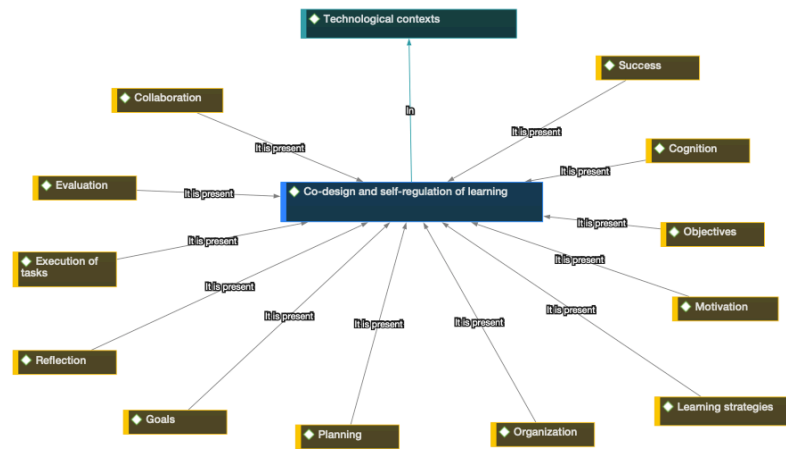
Figure 4 Common elements in the co-design and self-regulation models.

predictor of task success. That is, the more time spent planning, the better the results (Zimmerman, 2008). Self-assessment is the student's evaluation of the validity of their own work. This is based on established criteria, and the achievement standard that has been set for the activity **?**. These factors are also closely related to co-design, as if they are established beforehand, this will change the learner's perception of the task. Consequently, planning and motivation are linked to the learner's perception of his or her own learning in technological environments, and of the tasks to be performed.

The technological environments in which co-design-based projects are developed do not make reference to the concrete specifications of a model to be followed. But technology is emphasised as a support for graphic and visual representations, planning, the development of individual and/or collaborative tasks, and as a means of group communication. The research does not recommend or feature specific technological tools for developing co-design models. Instead, a combination of common tools is used in the stages of co-design, which are in turn linked to self-regulation models.

The results obtained through systematic review have enabled us to come up with the first draft of a co-design model that favours the process of self-regulation in technology-enhanced environments. Figure 5 shows sample size characterised by: level of co-design determined by interaction between the agents participating in the educational process (teacher-student-expert or other professionals); the roles and social relations inherent to participatory design; the stages within the self-regulation of learning based on Zimmerman (2000) and Zimmerman and Moylan (2009) cyclical model; and the technology used to support the whole process.
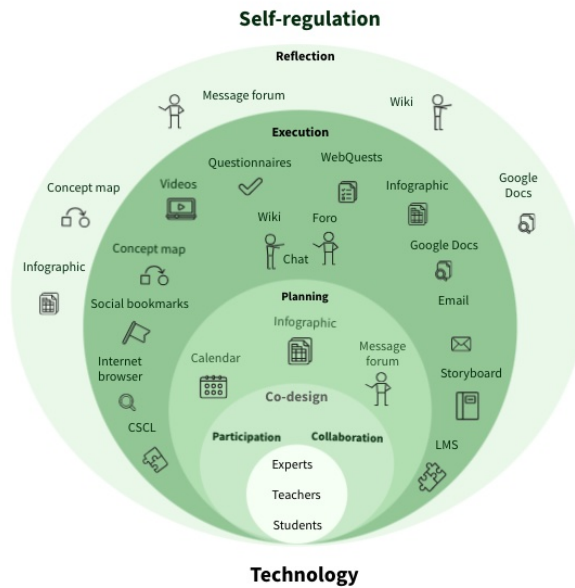
Figure 5 Tools related with self-regulation processes in the co-design of learning

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