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RESEARCH ARTICLE

Autorregulate: An Alternative to Support Self-Regulation in MOOCs

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ABSTRACT Massive Online Courses (MOOCs) suffer from the high desertion of enrolled students due to different factors, including bad time management by the participants, lack of planning, lack of help-seeking, and poor self-monitoring of their actions in the learning process, which suggests that students do not self-regulate their learning. Diverse software tools have been created to support MOOC participants by favouring self-regulated learning (SRL). However, there is still a lack of knowledge regarding how the different SRL model could be effectively, supported by ICT tools, what model inform in a better way the design of new tools to support SRL process in online setting, how the support of SRL affect the students' performance in a MOOC environment or what is the best way to integrally evaluate the impact of the tools supporting SRL. In this article, we introduce the design and development process of the Autorregulate tool, a web application that supports self-regulation of learning in MOOCs. This tool is developed within the framework of broader research employing research-based design (RBD) to create methodological and technological tools to facilitate self-regulation in MOOCs. Autorregulate supports seven learning self-regulation strategies: goal-setting, strategic planning, time management, help-seeking, self-monitoring, self-recording (Take Note), and self-assessment, considering the SRL model proposed by Zimmerman. The tool was evaluated in a MOOC created on Moodle, with 224 participants, over three evaluation dimensions: 1) Students SRL to measure the effect of the Autorregulate tool on the self-regulation of the participants' learning; 2) Autorregulate tool's usability and usefulness; and 3) Participants' interactions within SRL services. Results show participants' high level of self-regulation of learning after the intervention (M=4,3; SD=0,85) according to the online self-regulated learning questionnaire (OSLQ). On the other hand, 92% of participants considered the Autorregulate tool usable, and 97% considered the tool useful. Finally, results show SRL services are widely used by participants, especially those supporting the strategies with better performances by participants, according to OSLQ results. The findings of this study contribute to broadening the discussion regarding the use of ITC to support SRL on MOOCs.

INDEX TERMS MOOC, self-regulated learning, RBD methodology.

I. INTRODUCTION

Massive Open Online Courses (MOOC) are participatory and distributed courses with a publicly shared curriculum that support lifelong online learning [1]. Among the difficulties faced by participants on these courses, it is possible to highlight the great dropout of the participants due to different causes, such as courses poor quality, bad time management of the participants, lack of basic knowledge and skills, unsatisfactory learning experiences, lack of interaction with the

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instructor, lack of motivation, little attention to the diverse needs of the participants, or lack of strategies of the participants to self-regulate their learning [2].

As a result, various lines of research have been created in the field of MOOCs as an object of study, among which are the specification of the MOOC creation processes [3], [4], [5], gamification as a teaching strategy in MOOCs [6], the evaluation of the quality of MOOCs [7], the analysis of various types of interaction of the participants [8], [9], [10], accessibility in the contents of MOOCs [11], as well as support for Self-regulated Learning (SRL) [12], [13], [14], [15], [16], [17].

Self-regulation of learning is defined by Zimmerman [18] as the "process of forming self-generated thoughts, emotions, and actions that are cyclically planned and adapted to achieve personal goals." (p. 14). When a student cannot self-regulate his learning, he will likely abandon the activity he is developing due to different factors or situations faced, such as not having an appropriate work environment, not having created or planned the activities that will lead him to achieve the set of objectives, in addition to the poor distribution of time and the lack of follow-up and self-assessment of the activities".

Throughout history, the importance of self-regulation in the learning process of human beings has only increased. Several models have been developed in the fields of psychology and psychopedagogy that provide different perspectives on how the process of self-regulated learning can be understood and explained. Among these models, we can highlight those proposed by Zimmerman [19], Boekaerts [20], Winne y Hadwin [21], Pintrich [22], Efklides y Hadwin [23], Järvelä y Miller [24] that have been characterized and systematized by Panadero [25].

In the context of the Massive Open Online Courses is possible to support self-regulation from the beginning of the MOOCs designs, considering strategies such as the creation of guidelines to establish objectives, indicating at the beginning of the course the exact activities to execute and how would be the learning process, supporting time management through the use of calendars, facilitating the search for help using forums and chat, favoring self-monitoring through progress bar plugins, using wikis to facilitate note-taking and/or creating spaces for self-reflection in MOOCs, for example, through the use of questionnaires where the progress of the tasks might be auto-assessed. However, according with Cerón et al. a challenge observed in MOOC settings is the lack of a methodology that integrates both the theoretical conceptualization achieved on self-regulation and the means of strengthening it in the students using ICT tools [26].

Although the research on SRL in MOOCs is still scarce according to Alonso-Mencia et al. [27], ICT have been used to help self-regulate learning through software tools that help students focus on the task and their goals, providing scenarios to achieve them. In general, the available ICT solutions support students in activities such as the creation and planning of objectives, the specification of the temporary planning of activities, and monitoring and support throughout the process of carrying out the task. However, there are self-regulation strategies that ICT do not support yet, such as self-recording, self-consequences and environmental structuring. As well, another poorly supported such as time management, self-awareness, and organisation strategies. On the other hand, most of the available tools to support self-regulation in learning are not conceptually based on psychopedagogical models. As a result, there is little evidence to compare the effectiveness of different models to support self-regulation in MOOCs [28].

The objective of this research is to enhance our understanding of the crucial support required for self-regulated learning through ICT in MOOCs, contributing to enrich the discussion on this research line. For this purpose, Autorregulate is created, a tool that supports the participants' SRL strategies in a MOOC based on the theory of self-regulation of learning proposed by Zimmerman [19]. This tool was designed using the SCRUM methodology [29], and it was evaluated in the real context of a massive course offered in Moodle. Autorregulate offers new contexts to validate the use of ICT to support self-regulation and also new possibilities to compare with those tools based on others self-regulation model.

This article is structured as follows: Chapter 2 presents state-of-the-art tools designed to support SRL, identifying MOOC students' most effective self-regulation strategies according to the literature. Chapter 3 presents the research methodology followed in this study and describes the characteristics considered for designing and developing the Autorregulate tool, and Section IV presents the conclusions and future work. The research results may inform designers and programmers about new tools to be developed to support SRL in MOOCs.

II. RELATED WORKS

This section begins with the literature analysis of the recently reported papers about the self-regulation of learning in MOOCs and ends with the existing software tools that support the SRL.

The literature review carried out by Pérez Álvarez et al. [30] analysed different existing software tools to support self-regulation in MOOCs, concluding that there are very few and that they do not provide enough SRL features for student self-regulation. Based on their findings, the authors developed an application called NoteMyProgress, which was evaluated by four experts from different countries and 18 students. The results indicate that the experts positively evaluated the application as a tool to support the SRL, as well as the students, how consider the included features useful for managing time and organising their learning process. However, due to the short duration of the study, which was only two weeks, the tool was tested by very few users. Additionally, a single instrument, a concept evaluation test, was used for the evaluation, which failed to comprehensively

measure the self-regulation process achieved by students for their learning.

For their part, Onah et al. [31] carried out a study where the effectiveness of virtual and traditional teaching for an undergraduate course is analysed. eLDa is a platform for teaching computer concepts in a Python MOOC course. In the research, an online self-regulated learning questionnaire (OSLQ) was applied to 107 participants and was the instrument used to measure students' self-regulated learning skills. The results evidenced the effectiveness of blended teaching in the classroom for an undergraduate course. As a recommendation, the authors propose constantly providing combined online and traditional exercises to increase students' academic performance.

As usual, many of the available MOOCs focus on providing video conferences. In his studies, Robal et al. [32] designed a system called IntelliEye, which uses the students' webcams to determine, in real-time, the inattention moments of the students when they study the videoconferences, notifying them of the situation. IntelliEye makes students aware of these moments of inattention through visual and auditory signals, which is especially relevant since it supports self-monitoring students' learning. The authors implemented IntelliEye in a MOOC for 74 days and explored the extent to which the MOOC students accepted the intervention as part of their learning and how using this tool influenced the students' behaviour. They found that the majority of students (67%) are resistant to allowing the use of webcam-based attention-tracking techniques due to associated privacy concerns.

For their part, Sambe et al. [33] argue that bad self-regulatory skills are one of the key factors contributing to MOOC desertion. Therefore, they created a generic conceptual framework to promote self-regulated learning in a MOOC. This framework is a foundational structure for collaborating with a virtual partner to provide metacognitive guidance and visualise indicators—all with a primary focus on enhancing self-regulation in the learning process. As future work, they leave the creation and implementation of a virtual mate in a MOOC, based on the self-regulation literature, and evaluate the impact of the mate on the learning skills of Self-regulation in MOOCs.

In his studio, Alonso-Mencía et al. [27] introduced MOOCnager, a Chrome plugin to help learners improve their SRL skills. Specifically, this work focuses on goal setting, time management, and self-assessment. Each included area is in one of the 3 phases of the Zimmerman SRL cyclical modstate-of-the-arte inconclusive, as participants' use of the supplement was very low. However, students seem to prefer a tool integrated into the MOOC platform. This work is especially relevant because it is one of the few whose conceptual basis is the theory of self-regulation of learning proposed by Zimmerman [19].

In the last three years, the interest in supporting self-regulation has increased by several interesting studies.

In the year 2021, four studies were reported.

The research conducted by Han et al. [12] delves into the effects of self-regulated learning (SRL) tools on the academic writing proficiency of students learning English as a foreign language (EFL). Specifically, it examines how two technological tools, Lcourse and Lcourse+Pigai, impact students' writing performance, achievement in lexical complexity, and their perceptions of SRL strategies. The study reveals that these tools, particularly when used in conjunction, facilitate the development of SRL strategies and enhance writing performance, though they do not significantly improve lexical complexity. It underscores the importance of considering students' psychological study preferences when designing and implementing technology-supported SRL activities in academic writing contexts.

In a related vein, Van Der Graaf et al. [9] evaluate integrating various tools in virtual learning environments, including timers, highlighters, note-taking features, search tools, and planners, to support SRL processes. The study analyses participants' use of these tools and establishes correlations between participants' verbalised thoughts and the tools associated a priori with SRL processes, such as monitoring and planning. The identified correlations validate the efficacy of the tools in supporting SRL processes, providing valuable insights for the design of educational tools and strategies. One notable limitation of this study is the relatively brief intervention duration (45 minutes) and the instrumental nature of the tools employed. Some of the tools suggested in the study to support learning self-regulation are incorporated into this study.

Conclusively, the investigation by Han et al. [12] contributes valuable insights into the realm of technology-supported SRL tools and their impact on EFL students' academic writing competence. Similarly, Van Der Graaf et al. [9] shed light on the effectiveness of diverse tools in virtual learning environments to enhance self-regulated learning processes. Both studies emphasise the significance of considering psychological study preferences and provide practical implications for designing and implementing SRL interventions in educational contexts.

Finally, Mohammed et al. [17] conducted an exploration into the impact of self-regulated learning strategies, combined with learning management system tools, on enhancing creative writing skills in future English as a foreign language teachers. The study adopted a pre-post experimental design and demonstrated a significant improvement in participants' creative fiction writing, validating the effectiveness of integrating self-regulated learning with digital tools to enhance English as a foreign language writing skills. It underscores the role of systematic learning strategies and technological integration in facilitating more effective and creative language education approaches.

In the year 2022, Hsu et al. [34] presented their study on the design and effectiveness of the self-regulated learning user interface (SRLUI) in Massive Open Online Courses

(MOOCs). The research explores the impact of SRLUI on student persistence and learning outcomes in eight MOOCs. The study reveals that SRLUI, based on Zimmerman's SRL model, supports students in goal setting, task planning, and self-evaluation. Results indicate a high compliance rate (around 80%) among participants, although it did not significantly affect student persistence. However, the tool positively influenced learning outcomes, especially for high-performance groups, suggesting that SRLUI can effectively enhance learning in MOOCs. This study corroborates the findings of the research conducted in this present study.

In the year 2023, two studies were reported.

Psathas et al. [10] reported their study exploring the effectiveness of machine learning models in predicting student dropout rates in MOOCs, focusing on the impact of self-regulated learning (SRL) data. The study highlights the use of oversampling techniques to manage data imbalances, and it demonstrates that SRL data, along with participant records in MOOCs, such as employment status and chat usage, significantly improve the predictive capacity of these models. This research underscores the importance of incorporating SRL elements in predictive analyses of student participation and retention in online learning environments.

On their part, Cenka et al. [16] analyse the development of 'Diaria,' a learning journal tool designed to support SRL in online educational environments. The study emphasises the importance of SRL in digital learning, and it presents Diaria as a user-centred tool developed through a research design prototype and evaluated through usability testing with 30 participants. Results indicate good usability and provide insights into how such tools can be integrated into educational practices to enhance students' SRL skills, addressing the third wave of SRL measurements that combine measurement and intervention.

Focusing on software tools generated to support self-regulation, Table 1 showcases the most relevant studies in the literature, including the development of technological tools. The table includes the author and publication year, highlighting the tool developed in the study, the SRL model used to underpin the tool's design, as well as the main characteristics of the study.

Table 1 shows the limited utilisation of self-regulated learning models to underpin application designs (4/13); this is a crucial aspect to promote in this line of research, as the scientific foundation derived from assessments of self-regulated learning models can inform application designs, ensuring the development of applications that effectively support self-regulation of learning. Along the same line, evaluating tools designed based on SRL models as conceptual foundations could inform regarding the strengths and weaknesses of each model to support SRL strategies in online educational settings.

Continuing the analysis of self-regulation support tools, Figure 1 delineates the relationship between the tools identified in the literature and the self-regulatory strategies they endorse, updating the findings of Cerón et al. [26].

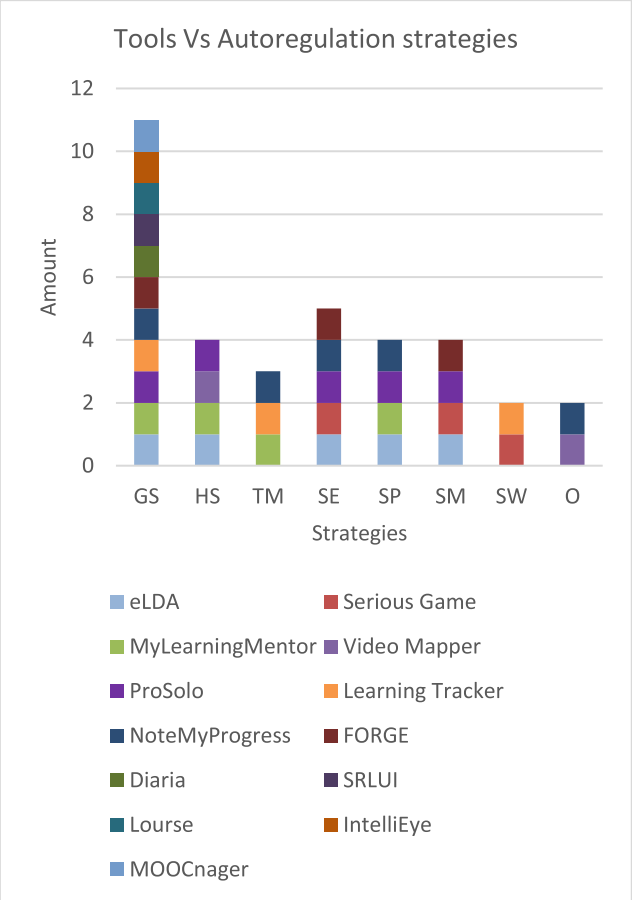

FIGURE 1. Tools vs regulatory strategies.

As can be seen, the self-regulation strategies most supported by the software tools identified in the literature are goal-setting and self-evaluation. Tools also support strategies of help-seeking, strategic planning, and self-motivation. For their part, time management, self-awareness, and organisation strategies are the least considered in the tools under study. The tools utilised in the studies do not support self-recording, self-consequences, and environmental structuring strategies.

The state of the art allows us to conclude that further research is needed to acquire sufficient evidence regarding the support for self-regulation strategies that have received limited backing and those not yet included in studies. Moreover, it is necessary to generate more evidence regarding how SRL strategies support students while they learn according to different self-regulation models.

In this present study, Autorregulate is presented as a tool that promotes self-regulation in MOOC's settings using Zimmerman's self-regulation model as a theoretical underpinning. The tool's design enriching the discussion on the efficacy of models to inform the development of self-regulated learning support tools and contributing with data that should compared with those obtained in future studies.

TABLE 1. Tools supporting SLR.

No	Author(s)	Year	Tool Name	SRL Model	Key Characteristic
1	Cenka et al. [16]	2023	DIARIA	N/A	Authors introduce the design and development of DIARIA, a learning diary tool for online education, and conduct a preliminary investigation into the impact of learning diaries on students' SRL skills. Autorregulate DIARIA is part of the third wave of SRL interventions, according to Panadero et al. [].Authors did not mention a specific model informing the design of DIARIA; however, they extracted general phases of the SRL process.
2	Hsu et al. [34]	2022	SRLUI	Zimmerman	Although authors did not mention explicitly the SRL strategies supported by this tool, according to the description provide by authors the strategies are goal settings, strategic planning y self-assessment. Authors UI influence on learning outcomes
3	Han et al. [12]	2021	Lourse, Lcourse+Pigai	N/A	Tools affecting EFL writing. No SRL model is informing the design of the tool.
4	Alonso-Mencía et al. [35]	2019	MOOCnager	Zimmerman	This tool supports three SRL strategies, goal setting, time management and self-assessment. The main limitation of the study the authors reported was the use of the plug-in was very low.
5	Robal et al. [32]	2018	IntelliEye	N/A	Webcam-based attention-tracking. No SRL model is informing the design of the tool.
6	Pérez-Álvarez et al. [30]	2017	NoteMyProgress	Pintrich	This tool includes features to support three self-regulation strategies: time-management, self-monitoring, and organising. Some limitations found by the authors are the number of students evaluating the tool (18), and some identified technical issues.
7	Onah et al. [36]	2017	eLDa	N/A	This study investigated students' perceptions of self-regulated learning (SRL) habits in the context of a module embedded in an eLDaMOOC platform for delivery of computing concepts and Python programme course. There is no SRL model informing the design of the tool.
8	Davis et al. [37]	2016	Learning tracker	N/A	Provides students with timely, goal-oriented information and feedback that encourages reflection and self-regulation. no SRL model is informing the tool's design.
9	Thirouard et al. [38]	2015	Serious game	N/A	This study introduces the production of the Sustainable Mobility MOOC, including the development of the Serious Game as a part of the evaluation process within the MOOC. There is no SRL model informing the design of the tool.
10	Alario-Hoyos et al. [39]	2015	MyLearningMentor	N/A	It is a mobile application that addresses the need for more personalised support and advice for students in MOOCs. There is no SRL model informing the design of the tool.
11	Yousef et al. [40]	2015	Video mapper	N/A	Video annotation tool that supports self-organised learning. There is no SRL model informing the design of the tool.
12	Unit & Innovation [41]	2015	Prosolo	N/A	Tool that supports the LLC no SRL model informs the tool's design.
13	Marquez-Barja et al. [42]	2014	FORGE	N/A	Teaches about self-regulated learning. There is no SRL model informing the design of the tool.

Conventions GS = Goal Setting, HS= Help-seeking, TM = Time Management, SE = Self-evaluation, SP = Strategic Planning, SM= Self-motivation, SW= Self-awareness, O = Organization.

Finally, the analysed studies by Cerón et al. [26] show a concise scale of validations, few individuals involved, and limitations in the evaluation concept, frequently based on one feature: the student's performance. This research enriches the evaluation methods employed in the studies by designing a more integral evaluation process that considers various assessment dimensions, students' SRL, the Autorregulate tool's usability and usefulness, and participants' interactions within SRL services.

III. CONTEXTUALISATION OF THE STUDY

The Autorregulate tool is developed in the context of the research called Contributions to support self-regulated learning in massive open online courses financed by the Ministry of Science, Technology, and Innovation of Colombia (Minciencias). The main objective of this study was to develop a methodological strategy supported by ICT to support the self-regulation of learning participants in massive online courses, based on Zimmerman's model of self-regulation of learning, to evidence the impact of the strategy on the capacity of individuals' self-regulation of learning in MOOC.

This research pursues two fundamental objectives: first, to design a methodological strategy to support the self-regulation of learning in MOOCs, considering the cycle of self-regulation of learning defined by Zimmerman, and second, to develop a technological tool that facilitates MOOC participants' self-regulation of learning.

The research is based on the methodological framework of Research-Based Design (DBR), defined by Wang et al. [43] as ''a systematic but flexible methodology aimed at improving educational practice through iterative analysis, design, development, and implementation, based on the collaboration of researchers and practitioners in a real environment and that pursues design principles and context-based theory'' (p. 6).

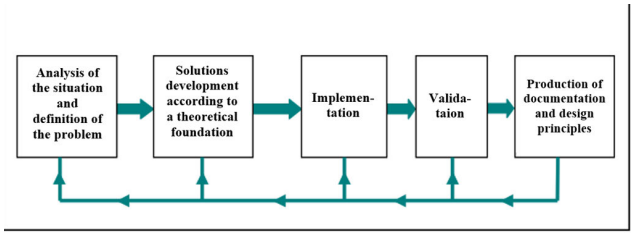

FIGURE 2. DBR methodology.

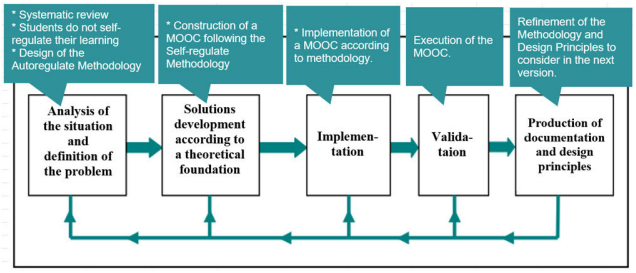

FIGURE 3. First iteration.

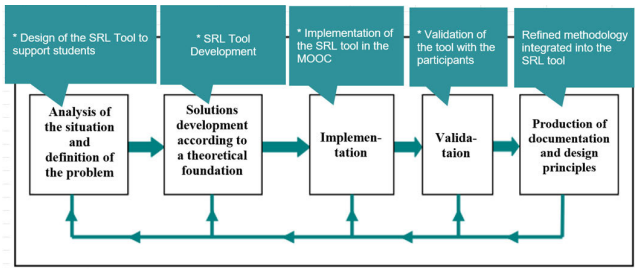

FIGURE 4. Second iteration.

TABLE 2. Scrum team.

Role	Characteristic	Function	Quantity
Product Owner	Software owner	Generate the requirements.	1
Scrum Master	Project manager	Coordinate the team in project development.	1
Development Team	Developer	Responsible for creating the software.	2
	Systems analyst	Responsible for conducting feasibility studies, analysing, and designing the tool.	1

The DBR methodology drives the solutions design of for problems detected in education using current scientific theories or models. Figure 2 depicts the iterative process proposed by DBR, which consists of five phases: analysis of the situation and definition of the problem, solutions development according to a theoretical foundation, implementation, validation, and production of documentation and design principles.

As mentioned, the process of the DBR methodology is iterative, and in the study, two iterations or moments were developed.

Figure 3 summarises the first iteration carried out. During the Situation Analysis, a systematic literature review was conducted [26]. Based on it, the Self-regulate Methodology was designed to support the creation of MOOCs that facilitate the self-regulation of the learning of the participants in the MOOC [44] (In Press). While creating a MOOC, this methodology underwent an evaluation leading to design principles that refined it. The evaluation also brought to light specific needs that the methodology could address. One such identified need is the requirement for technical support to assist participants in the MOOC with self-regulating their learning.

Figure 4., summarises the second iteration designed. In it during the moment of Analysis, the need for the participants in the MOOC to have technical support that would help them self-regulate their learning emerged, and a tool called Autorregulate appeared as a solution during the development moment of solutions. A new evaluation scenario is designed and executed in the context of a second MOOC developed, integrating the Self-Regulate tool in MOODLE, where the MOOC was created to support students during Implementation. This new scenario was evaluated during the validation moment, which included the findings of the evaluation inputs for a refinement of the methodology and the tool.

In this paper, the *second iteration of the research is detailed.* In the next section, we present the design and development details of the Autorregulate Tool.

IV. AUTORREGULATE TOOL

The main objective behind the design of Autoregulate is to support the participants in a MOOC to self-regulate their learning, contributing to reduce dropout. As mentioned, the theoretical basis for creating the tool is Zimmerman's self-regulation model, which works in three phases: Planning, Execution and Self-reflection.

The Autoregulate tool specifically supports seven strategies from the three phases of self-regulation of learning. The planning phase supports goal setting and strategic planning; the Execution phase supports time-management strategies, help-seeking, self-monitoring, self-registration (take note); and finally, the self-reflection phase supports the self-assessment strategy [19].

A. DEVELOPMENT METHODOLOGY

The creation of Autorregulate, considered the recommendations of the SCRUM framework for agile development [45]. The process followed to develop the Autorregulate tool is shown in Figure 4.

The Autorregulate tool development team consisted of five members: the Product Owner, the Scrum Master, and a Development team with three individuals as indicated in Table 2.

The Product Owner provided a backlog to the SCRUM Master. Three modules were defined to be developed:

TABLE 3. Tool feature list.

Nro.	Module	Description
1	Self-regulation strategies	The services to support the seven learning self-regulation strategies are Goal Setting, Strategic Planning, Time Management, Help Seeking, Self-Monitoring, Self-Recording (Take Note), and Self-Assessment.
2	Analytics	The module monitors the participation of individuals while using the services that support the self-regulation strategies during the MOOCs execution.
3	Help	This module provides help to users, providing videos corresponding to the menus of the Self-regulate tool are created.

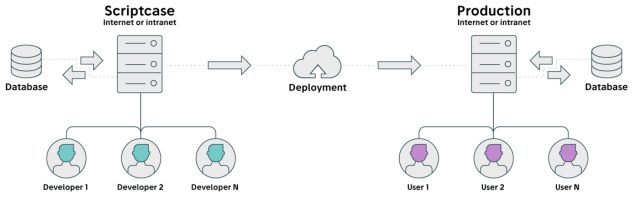

FIGURE 5. Scriptcase structure.

1) self-regulation strategies, 2) analytics, and 3) help. These modules are described in Table 3.

As mentioned before, the selection of the seven self-regulation strategies to be supported by Module 1 was based on the findings of the systematic literature review [26]. In particular, we have selected the most useful to students and some less supported by the available software tools.

After defining the modules, a work plan was designed with a schedule organised in days and hours for executing the sprints corresponding to the project's development.

B. DEVELOPMENT ECOSYSTEM

On the ecosystem used in the development process, the Scriptcase software development tool was used to generate the application code under the Rapid Application Development (RAD) scheme. Scriptcase covers a framework composed of an element series and complements to generate grids, filters, graphs, pdf reports, forms, navigation menus, data export to doc, xls, CVS, and XML, security modules with login and user and group levels [46].

Scriptcase offers the flexibility to install the software locally or on an internet server, such as an intranet or hosting platform; this allows for easy access to the tool from any browser, enabling multiple users to work on the same project simultaneously, as illustrated in Figure 5.

As Rouse [47] described, the MySQL database management system was used to create the database. It is an open-source relational database management system (RDBMS) based on Structured Query Language (SQL). MySQL offers a fast and robust multi-user server for executing instructions in parallel, meaning multiple users distributed throughout a local network or the Internet will be able to execute different tasks on the databases located on the same server [48].

For the development of the tool, we also worked with PHP, which stands for Hypertext Pre-Processor. It is a general-purpose programming language with an Open-Source license that runs on the server side and has multiple uses since it can be with scripts, in a structured way, or with object programming.

The development of the tool involved the utilisation of HTML5, which is the latest HTML language specification and includes remarkable advantages such as promoting semantic (meaningful) markup, separating design from content, promoting accessibility and design responsiveness, reducing overlap between HTML, CSS, and JavaScript, support rich media experiences, and eliminate the need for plugins like flash or java [49].

CSS3 was employed for style management, utilising a technology that has undergone significant advancements and is denoted by the acronym ''Cascading Style Sheets'' [50].

As for the web server, Apache was used, which is a free web server created by the Apache Server Project [51].

It should be taken into account that the MOOC courses used in the research were implemented in the educational platform LMS Moodle, integrating the Autoregulate tool into this platform to work with course data such as activities, questionnaires, database records, and more. Data were needed in the tool in such a way that it could be used to generate analytics regarding self-regulation strategies.

C. AUTORREGULATE DEVELOPMENT METHOD

1) DESIGN PHASE

During the design phase was modeled how the Autorregulate tool would support students in the self-regulation process of learning. Table 4 compares student activities using and not using the self-regulate tool. To be more specific, a comparison was to support what the student would receive regarding self-regulation strategies.

Table 5 shows the functionalities offered to the student in Autorregulate for each self-regulation strategy.

In next section, it is explained how supporting each of these strategies was implemented in the Autorregulate tool.

2) DEVELOPMENT

Each functionality associated with supporting the seven self-regulation strategies, supported by the Autorregulate tool, is described below.

GOAL SETTING

The goal-setting strategy is one of the first actions carried out in Autorregulate, listing all the activities created in the MOOC and making it easier for the participant to set their goals for each week, regardless of how they set out in the original scheme of the MOOC. In this sense, the student in a week, according to the availability of time, can decide whether to do one or several activities, managing their achievements in the

TABLE 4. Changes in learning self-regulation processes due to the use of the autorregulate tool.

Current activities	Proposed activities
Goal Setting: Students create their goals manually.	The created Objectives are made with the tool and saved in the database.
Stratenning: Students cannot carry out strategic planning where they can create objectives with their respective times.	Students can plan strategically by analysing the best way to develop the objectives in the proposed times.
Time management: In certain programs, students manage their time without linking their activities to the relevant ones on the platform.	Students can manage time, connecting directly with the activities created on the Moodle platform.
Seeking Help: Students seek help in a traditional way using Internet search engines or by contacting their classmates through external means.	Students seek help within the tool by creating forums according to the activities proposed, where the resolved doubts serve other students.
Self-monitoring: Students cannot monitor activities already done.	Students can self-monitor the activities they are engaged in by using the tool provided by Autorregulate.
Self-Registration: Students' notes are made in a physical document or online without an order.	The notes are stored in the tool's database in chronological order.
Self-assessment: Students do not have the tools to self-assess their process.	Students can have their academic process evaluated weekly.

TABLE 5. Autorregulate tool design.

Learning Self-regulation Strategy	Action to take
Goal Setting	Create goals from Moodle activities
Strategic planning	Carry out planning, combining objectives and time management.
Time management	Distribute the times in minutes, hours, and days for each activity.
Help-seeking	Ask their peers, creating forums.
Self-monitoring	Check video statistics like views, pauses, total plays Last accesses to the course, and the most effective day of the week.
Self-registration	The student adds notes of the most relevant to be able to consult at any time.
Self-assessment	The student has a dashboard where she can evaluate her learning process per week.

development of the MOOC. Figure 6 shows a screenshot of this functionality.

STRATEGIC PLANNING

Strategic planning is of vital importance when participating in a MOOC. Autorregulate allows the participant to create an entire schedule of activities, discriminating between planned, completed, and pending activities. Figure 7 shows a screenshot of this functionality.

TIME MANAGEMENT

Time management is considered one of the most crucial and definitive strategies that a MOOC participant must adopt to complete the course. Figure 8 shows the functionality offered in Autorregulate that allows participants in a MOOC to manage their time, either in days of the week, hours, or minutes. The analytics generated by the tool allow the participant to know which day and hour has been the most effective time dedicated per week and the time for activities, as shown in Figure 9.

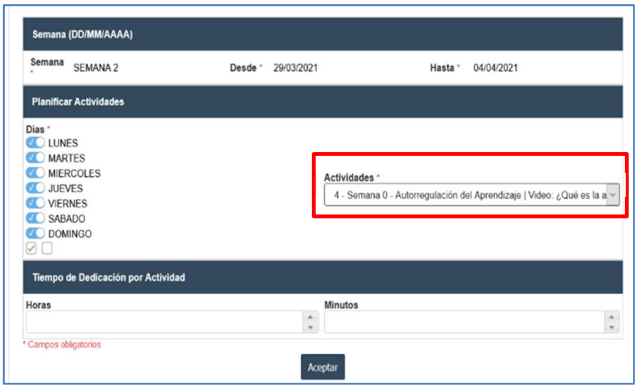

FIGURE 6. Goal setting.

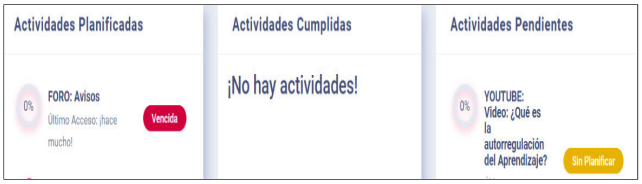

FIGURE 7. Strategic planning.

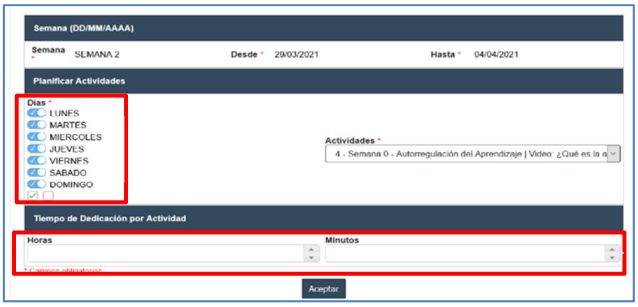

FIGURE 8. Time management.

FIGURE 9. Time management analytics.

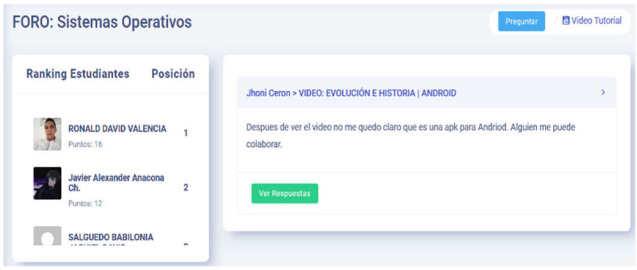

FIGURE 10. Forums.

FIGURE 11. Video analytics.

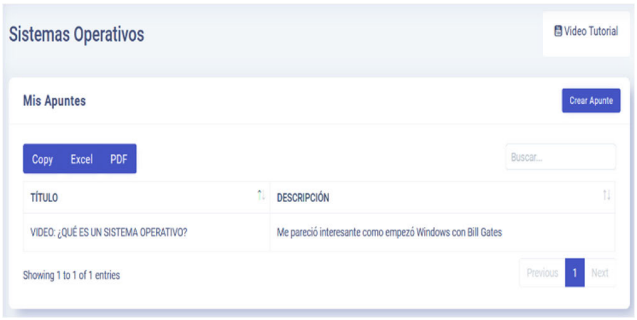

FIGURE 12. Notes.

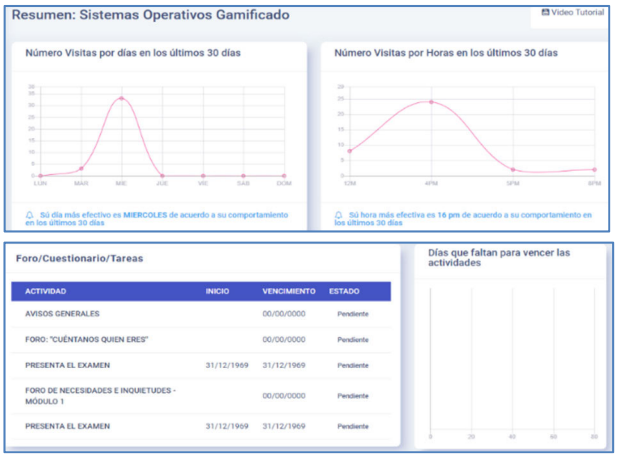

FIGURE 13. Self-assessment.

HELP-SEEKING

Help-seeking self-regulation strategies allow participants to overcome problems they encounter during the MOOC. The functionalities offered by Autorregulate enable participants to know the best answers to specific queries since the posts in the forums have a score that helps generate a ranking. This strategy also increases the motivation to collaborate. Figure 10 shows a screenshot of this functionality.

SELF-MONITORING

The self-monitoring strategy in Autorregulate allows the MOOC participant to be able, in real-time, to observe the different actions carried out in the MOOC and thus improve or correct situations as they arise. Autorregulate shows the participant the video statistics as views, pauses, and total reproductions, as shown in Figure 11.

SELF-RECORDING

Autorregulate facilitates the MOOC participant's self-recording or annotation, creating notes of the most relevant topics seen in the MOOC and allowing them to consult in real-time. Figure 12 shows a screenshot of this functionality.

SELF-ASSESSMENT

In the self-assessment strategy, students can visually analyse their progress in the MOOC weekly. The functionality highlights the activities that remain to be developed, as shown in Figure 13. As can be seen, among other activities, tasks, forums, and questionnaires already completed or pending are detailed. Also, it shows the dates of access.

As mentioned before, previous studies shown limitations in the evaluation concept, which was frequently based on one feature. To overcome this limitation next section introduce the multi-dimensional evaluation designed to validate the Autorregulate tool.

3) EVALUATION

The Autorregulate evaluation considered three fundamental dimensions: 1) the effect of Autorregulate on the self-regulation of the participants' learning; 2) the usability and usefulness of Autorregulate as a tool and 3) the behaviour of the participants' interactions for self-regulation strategies with Autorregulate.

ASSESSMENT SCENARIO

The self-regulate evaluation was carried out in the context of the execution of the MOOC called "Operating Systems", with the main objective of facilitating the competence to manage an operating system, including the ability to administrate the hardware.

The MOOC was implemented in the domain https://vivelaeducacion.com/cursos/.

The access link to Autorregulate tool was: https://vivelaeducacion.com/autorregulate/. It was available main page of the course as shown in Figure 14.

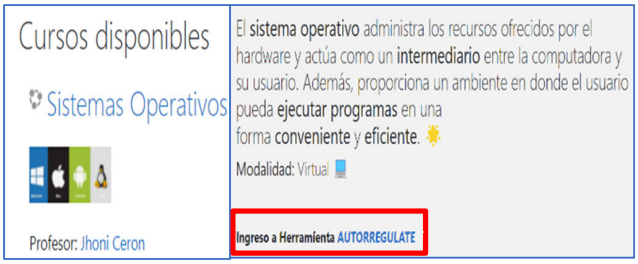

FIGURE 14. Access to the tool.

TABLE 6. Gender of the participants.

Gender	Quantity	%
Men	122	54,5
women	102	45,5
Total	224	100

PARTICIPANTS

The MOOC was offered for all the Luis Carlos Galán school students in Villagarzón city, located in the Department of Putumayo in Colombia. 224 students participated in the study. The participants were 102 women (45.5%) and 122 men (54.5%), aged between 11 and 13 years, as indicated in Table 6. As can be noticed the course shows a balanced sample.

An informed consent was requested to be signed by the students' parents due participants in the study were minors.

METHOD

The MOOC course began on April 5, 2021, and ended on April 30, 2021. Completion dates were estimated for each module, distributed as follows:

•From April 5 to April 9, 2021, the development and fulfilment of all activities by students of modules 0 and 1.

•From April 12 to April 16, 2021, development and completion of all modules two activities.

•From April 19 to April 23, 2021, the completion of the activities by the students of module 3.

•From April 26 to April 30, 2021, the last module of the operating systems course, module 4, should be completed.

After the development of the MOOC, the participants filled out the data collection instruments.

On the other hand, the participant's interactions with the self-regulation tools were recorded in real-time in the application's storage system.

The consent of the Luis Carlos Galán School's ethics committee regarding the research design of the study is available at the project repository [https://osf.io/download/x6zms/?direct%26mode=render].

TABLE 7. Reliability coefficients for OSLQ.

Num.	Strategy	Ítems	Cronbach alpha
1	Goal setting	5	0.73
2	Environmental structuring	4	0.79
3	Task strategies	4	0.71
4	Time management	3	0.82
5	Help-Seeking	4	0.67
6	Self-Assessment	4	0.76
Total		24	0.75

TABLE 8. Levels of self-regulation scenario 2.

Range	Likert Scale	Levels of self-regulation
0 a 1,99	Totally disagree	Insufficient
2 a 2,99	Disagree	Low
3 a 3,99	Neither agree nor disagree	Basic
4 a 4,59	Agree	High
4,6 a 5	Totally agree	Superior

INSTRUMENTS

The instruments used as data collection tools are detailed below.

Online Self-Regulated Learning Questionnaire (OSLQ)

Online Self-Regulated Learning Questionnaire [52] is a questionnaire that consists of 24 items with a Likert-type response format of 5 points with values from totally agree (5) to totally disagree (1). OSLQ assesses six self-regulation strategies: environment structuring, goal setting, time management, help-seeking, task strategies, and self-assessment.

The scores obtained from the measure showed an adequate internal consistency of scores with α =.75. Nunnally [53] suggested that the score reliability of.70 or higher is acceptable when used in basic social science research, as in this study. When checking the internal consistency of the subscale scores, Cronbach's alpha values ranged between 0.67 and 0.82, which reveals sufficient reliability of the score at the subscale level. Table 7 contains internal consistencies for the scores obtained from each subscale.

Regarding the five-point Likert scale, a new variable called self-regulation level was calculated based on the rating scales of the questionnaire items. Table 8 shows that the five scales are grouped into five levels of self-regulation: insufficient, low, basic, high, and superior.

Strategies not evaluated using the OSLQ are assessed using participants interaction in the provided tools. On the other

hand, environment structuring is a strategy not supported by the Autorregulate tool, but the instrument evaluates it.

Usability and usefulness survey of Autorregulate.

To evaluate the usability and usefulness of Autorregulate, the instrument designed by [54] was used, and its voluntary completion is depicted in Table 9.

DATA ANALYSIS

The statistical analysis of the data in the present study was carried out using IBM SPSS version 26.

RESULTS

Results of the evaluation of the effect of Autorregulate on the self-regulation of the participants' learning

The descriptive statistical analysis of the data collected through the OSLQ instrument showed a general mean of 4.3, with a standard deviation of 0.85, which indicates a high degree of self-regulation strategies in the participants. (See Table 10).

As in Table 9, a high level of self-regulation at the level of each of the six scales, ranging from a mean of 3.96 with SD 0.91 in the help-seeking strategy, to a mean of 4.66 with SD 0.80 for the environment structuring strategy.

The relationship between the two regulation strategies subscales was also analysed. Pearson's correlation was applied to conduct the analysis. Consequently, the result was a strong relationship between the scales when tested in pairs since the significance value of all the pairs was $p > .001$, and the correlation was between 0.409 and 0.787. As seen in Table 11, the strongest relationship between the two strategies was time management and goal setting, with a correlation of 0.787. $P < .01$.

From the analysis of the OSLQ survey, it is possible to conclude that the participants in the ''Operating Systems'' course self-regulated their learning in the context of the designed MOOC.

Results of the evaluation of usability and usefulness of the Autorregulate tool.

The results report that 60.8% of the students answered that the tool was straightforward, 31.1% easy, and only 8.1% said it was somewhat easy, as seen in Figure 15. Therefore, we conclude that the Autorregulate tool is easy to use for almost all participants.

The results on the usefulness of the tool report that 68.9% of the students said it was very useful, 28.4% said it was useful, and only 2.7% said it was somewhat useful, as seen in Figure 16. Based on the information provided, evidence suggests that the tool effectively serves its intended purpose of assisting students in regulating their learning, particularly by supporting the implementation of six SRL strategies.

Results of the Evaluation of the Interactions of Self-regulation Strategies with the Autorregulate Tool

As indicated, the interactions analysed are related to the functionalities associated with the self-regulation strategies as indicated in Table 12.

TABLE 9. Usability and usefulness instrument.

Q	CATEGORY	DESCRIPTION
1	USABILITY	The tool informs me about the action I am developing.
2		For each action I perform on the tool, I can know the results of the action.
3		The tool only performs the actions that I have instructed it to do.
4		The written texts used in the tool are easy to interpret.
5		The visualisations presented in the tool are easy to interpret.
6		Information is accessible in a logical and easy-to-understand order.
7		I can freely select the information to display.
8		I can exit the tool anytime I want.
9		The tool works the way I want it to work.
10		The convention used (standards or how the information is presented) is consistent on all the tool pages.
11		The convention used in the tool is similar to those I have used in other tools.
12		The same graphical components are used to perform the same actions on all tool pages.
13		There is a clear relationship between the controls used in the tool and its actions.
14		Instructions on how to use the tool are visible.
15		Used objects, such as graphics and toolbars, are visible.
16		Each page used in the tool contains the information that I need.
17		The use of graphics or images in the tool is appropriate.
18		The selection objects and menus present me with the options required to be able to choose between the options.
19	USEFULLNESS	The information presented in the visualisations is relevant or important to me.
20		The information presented in the visualisations allows us to know what my interaction with the course has been.
21		The information shown in the visualisations allows me to know what my commitment to the course has been.
22		The information presented in the visualisations allows me to know how I have spent my time in the course.
23		The information presented in the visualisations allows you to know what my interaction with the course activities has been.
24		The visualisations provide information that can help me be aware of the time I spend in the course.
25		Dialog boxes (messages that visualisations show when you hover over them) present relevant information.
26		The tool presents information that allows me to reach conclusions about the use of the course.

Table 13 summarises the interactions by students of the MOOC course with each of the seven supported strategies: Self-assessment, Self-monitoring, Self-registration, Help-seeking, Goal-setting, Time-management, and Strategic-planning.

TABLE 10. Descriptive statistical analysis of the OSLQ instrument.

No	Strategy	N	Mean	Levels of self-regulation	Standard Deviation (SD)
1	Goal setting	224	4.39	High	0.76
2	Environmental structuring	224	4.66	Superior	0.80
3	Task strategies	224	4.14	High	0.86
4	Time management	224	4.34	High	0.92
5	Help-Seeking	224	3.96	Basic	0.91
6	Self-Assessment	224	4.30	High	0.88
	Total	224	4.30	High	0.85

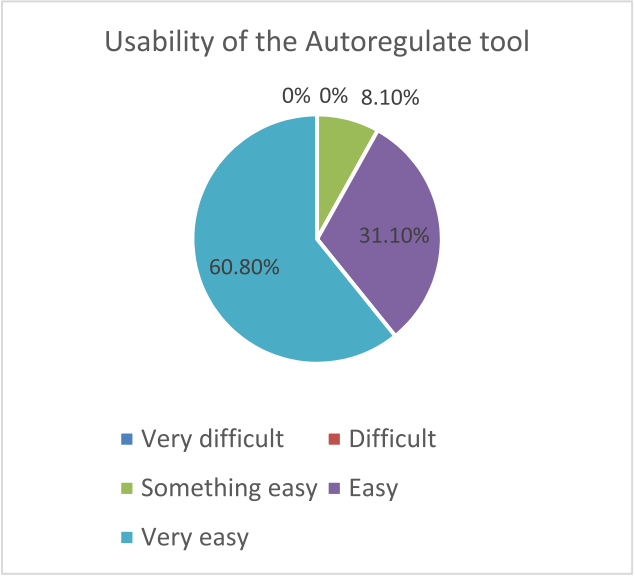

FIGURE 15. Usability of the Autorregulate tool.

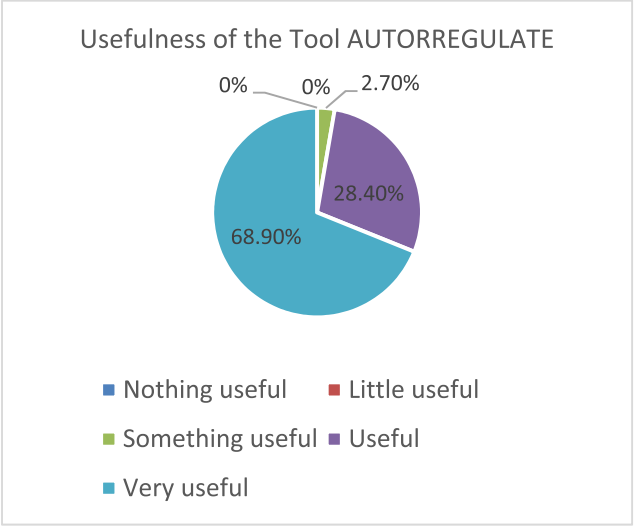

FIGURE 16. The usefulness of the Autorregulate tool.

Figure 17 shows the percentage of interactions carried out in each of the strategies. The figure shows that the most used strategy by students was self-monitoring at 27.8%, time management at 19.5%, and strategic planning at 18.7%.

TABLE 11. Pearson correlation between SRL scales.

		1	2	3	4	5	6
1	GS	-					
2	ES	0.652	-				
3	TS	0.633	0.481	-			
4	TM	0.787	0.517	0.69	-		
5	HS	0.543	0.409	0.574	0.553	-	
6	SA	0.717	0.523	0.617	0.625	0.742	-

Units: GS= Goal setting, ES= Environment structuring, TS= Task strategies, TM= Time management, HS= Help-Seeking, SA= Self-assessment.

TABLE 12. Self-regulation strategies for learning and interactions.

Strategies	Interactions
Goal Setting	Interactions made from Moodle activities are set as goals in the tool.
Strategic planning	Related to the interactions made with the Planning menu.
Time management	These are the interactions regarding dedicated time per activity.
Help-Seeking	Interactions are made with the forum, where the user can ask for and obtain help on topics presented in the MOOC.
Self-monitoring	Interactions are made with the summary menu, where a series of actions such as video statistics (views, pauses, total reproductions), Last accesses to the course, and the most effective day of the week are given to the participant.
Self-registration	Interactions related to the note's menu.
Self-Assessment	The interactions generated when students access the dashboard may evaluate their learning process per week.

TABLE 13. Interactions of the participants with self-regulation strategies.

Self-regulation Strategies		
STRATEGY	INTERACTIONS	STUDENTS
Self-assessment	30	16
Self-monitoring	181	56
Self-registration	40	18
Help-seeking	64	23
Goal setting	87	23
Time management	127	22
Strategic planning	122	25

DISCUSSION

Results provide promising evidence that the Autoregulate tool can effectively support participants' implementation of self-regulated learning strategies in MOOC settings.

High self-regulation scores on the OSLQ indicate that participants successfully regulated their learning while using Autoregulate during the "Operating Systems" MOOC; this aligns with previous research showing the benefits of incor-

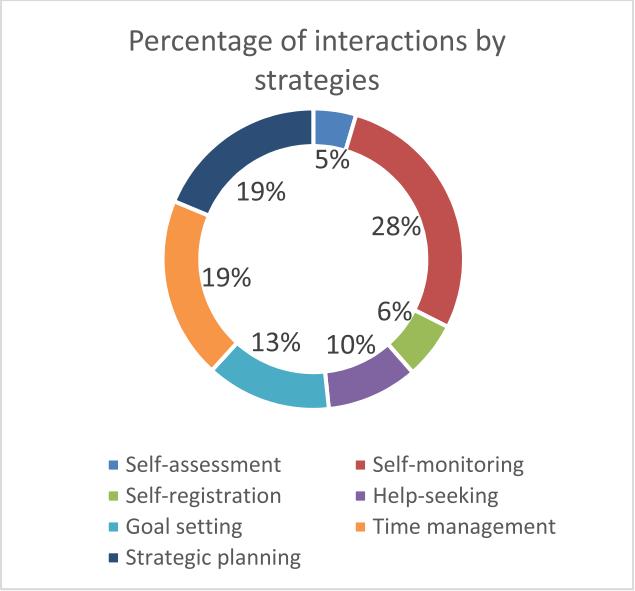

FIGURE 17. Percentage of interactions by strategy.

porating support for self-regulated learning into online courses [13], [32], [36].

In particular, the OSLQ results demonstrated high levels of goal setting, environmental structuring, task strategies, time management, and self-assessment among the participants, which suggests that the tool's functionalities made it easier for students to implement these key SRL strategies. Moreover, the help-seeking score was lower compared to the others, although still in the basic self-regulation range. Additional scaffolding within the Autoregulate help-seeking forums may be needed to facilitate this strategy further.

The strongest correlations between time management and goal-setting strategies indicate the interdependence of these two processes. The previous idea aligns with Zimmerman's emphasis on anticipatory planning, such as goal setting and strategic planning [18], and the idea that time management is necessary to support goal achievement. Perez-Alvarez et al. similarly, these authors found positive impacts by supporting these strategies in their NoteMyProgress tool [55].

The overall ratings derived from the usability and usefulness survey demonstrate high students' acceptance and perceived value of the Autoregulate tool. In particular, they showed that the Autorregulate tool is very easy to use (60.8%) and handy (68.9%). This extends the usability results of previous tools, such as NoteMyProgress and video annotation tools [40], [54].

Furthermore, analysing student interactions on the Autoregulate tool provides information on their use during the MOOC. The intensive use of self-monitoring features suggests that participants found these progress-tracking features helpful in maintaining their engagement and learning in the course. Giving visibility to their learning processes seemed to allow for better self-reflection. This reinforces the importance of self-control and metacognition in self-regulated learning models [19], [21].

LIMITATIONS

This study presents some limitations that should be addressed in future research. The sample consisted of high school students. Additional research is needed to assess the self-regulation support provided by the Autorregulate tool within a more diverse MOOC learners. On the other hand, longer-term studies with students from diverse areas of knowledge could also enrich evidence regarding the tool's impact on MOOC completion rates.

V. CONCLUSION

This research aimed to present the design and evaluation process of Autorregulate, a tool designed to support the implementation of SRL strategies by students in MOOCs. We present the design and development process, followed by an evaluation in a MOOC called Operative Systems by 224 students.

According to this study, the Autorregulate tool highly supports goal setting, environmental structuring, task strategies, time management, and self-assessment among the participants. On the other hand, Autorregulate allows participants to self-monitor their advantage at any time during the course.

This research contributes to the state of the art on SRL supported by ICT, giving inputs to reinforce the importance of SRL in the MOOC context, providing additional tools to monitor and promote the implementation of SRL strategies by participants and providing results to compare with other related studies.

REFERENCES

[1] A. McAuley, B. Stewart, G. Siemens, and D. Cormier. (2010). *Massive Open Online Courses. Digital Ways of Knowing and Learning. The MOOC Model for Digital Practice*. [Online]. Available: http://davecormier.com/edblog/wp-content/uploads/MOOC_Final.pdf

[2] C. Gütl, V. Chang, R. H. Rizzardini, and M. Morales, "Must we be concerned with the massive drop-outs in MOOC? An attrition analysis of open courses," in *Proc. Int. Conf. Interact. Collaborative Learn.*, 2014, pp. 1–8.

[3] C. Alario-Hoyos et al., "Diseñando un MOOC en edX: Introducción a la Programación con Java—Parte 1," Jornadas Ing. Telemática, Palma de Mallorca, España, pp. 391–398, 2015.

[4] A. Meléndez, M. Romén, and R. Pinillos, "Guía práctica: Gestión, producción, infraestructura y control de calidad para MOOC," *Sánchez, J. Editor. Nuevas Ideas en Informática Educativa*, vol. 12, pp. 372–377, Jan. 2016.

[5] K. B. Montoya, M. D. J. H. García, F. C. Fuscaldo, and M. M. Lourido, "Diseño instruccional de un curso MOOC en la red social Facebook," *Revista de Investigación Educativa del Tecnológico de Monterrey*, vol. 10, pp. 2–10, Jan. 2019.

[6] M. Khalil, J. Wong, B. De Koning, M. Ebner, and F. Paas, "Gamification in MOOCs: A review of the state of the art," in *Proc. IEEE Global Eng. Educ. Conf.*, Apr. 2018, pp. 1629–1638, doi: 10.1109/EDUCON.2018.8363430.

[7] M. Zhu, A. Sari, and M. M. Lee, "A systematic review of research methods and topics of the empirical MOOC literature (2014–2016)," *Internet Higher Educ.*, vol. 37, pp. 31–39, Apr. 2018, doi: 10.1016/j.iheduc.2018.01.002.

[8] J. Maldonado-Mahauad, M. Pérez-Sanagustín, P. M. Moreno-Marcos, C. Alario-Hoyos, P. J. Muñoz-Merino, and C. Delgado-Kloos, "Predicting learners' success in a self-paced MOOC through sequence patterns of self-regulated learning," in *Proc. Eur. Conf. Technol. Enhanced Learn.* (Lecture Notes in Computer Science), vol. 11082, 2018, pp. 355–369, doi: 10.1007/978-3-319-98572-5_27.

[9] J. Van Der Graaf, L. Lim, Y. Fan, J. Kilgour, J. Moore, M. Bannert, D. Gasevic, and I. Molenaar, "Do instrumentation tools capture self-regulated learning?" in *Proc. 11th Int. Learn. Anal. Knowl. Conf.*, 2021, pp. 438–448, doi: 10.1145/3448139.3448181.

[10] G. Psathas, T. K. Chatzidaki, and S. N. Demetriadis, "Predictive modeling of student dropout in MOOCs and self-regulated learning," *Computers*, vol. 12, no. 10, p. 194, Sep. 2023, doi: 10.3390/computers12100194.

[11] S. Sanchez-Gordon and S. Luján-Mora, "Research challenges in accessible MOOCs: A systematic literature review 2008–2016," *Universal Access Inf. Soc.*, vol. 17, no. 4, pp. 775–789, Nov. 2018, doi: 10.1007/s10209-017-0531-2.

[12] Y. Han, S. Zhao, and L.-L. Ng, "How technology tools impact writing performance, lexical complexity, and perceived self-regulated learning strategies in EFL academic writing: A comparative study," *Frontiers Psychol.*, vol. 12, pp. 1–18, Nov. 2021, doi: 10.3389/fpsyg.2021.752793.

[13] D. Lee, S. L. Watson, and W. R. Watson, "Systematic literature review on self-regulated learning in massive open online courses," *Australas. J. Educ. Technol.*, vol. 35, no. 1, pp. 28–41, Mar. 2019, doi: 10.14742/ajet.3749.

[14] R. Pérez-Alvarez, J. Maldonado-Mahauad, and M. Pérez-Sanagustín, "Tools to support self-regulated learning in online environments: Literature review," in *Proc. Eur. Conf. Technol. Enhanced Learn.* (Lecture Notes in Computer Science), vol. 11082, 2018, pp. 16–30, doi: 10.1007/978-3-319-98572-5_2.

[15] G. Sambe, F. Bouchet, and J. M. Labat, "Towards a conceptual framework to scaffold self-regulation in a MOOC," in *Proc. Conf. Nationale Sur La Recherche En Informatique Et Ses Appl.* (Lecture Notes in Computer Science), vol. 204, 2018, pp. 245–256, doi: 10.1007/978-3-319-72965-7_23.

[16] B. A. Nan Cenka, H. B. Santoso, and K. Junus, "The third wave of self-regulated learning's measurement and intervention tools: Designing 'diaria' as a new generation of learning diary" *Int. J. Emerg. Technol. Learn. (iJET)*, vol. 18, no. 9, pp. 216–242, May 2023, doi: 10.3991/ijet.v18i09.35605.

[17] E. Mohammed, A. M. Zaher, A. E. Khater, and H. Abdullah, "Using self-regulated learning with learning management system tools to develop EFL student teachers' creative writing," *Buhūth*, vol. 1, no. 12, pp. 70–100, 2021, doi: 10.21608/buhuth.2022.146486.1355.

[18] B. J. Zimmerman, "Attaining self-regulation. A social cognitive perspective," in *The Handbook of Self-Regulation*, B. Monique, Z. Moshe, and P. Paul, Eds. San Diego, CA, USA: Academic Press, 2000, pp. 13–39.

[19] B. J. Zimmerman and A. R. Moylan, "Self-regulation: Where metacognition and motivation intersect," in *Handbook of Metacognition in Education*. New York, NY, USA: Routledge/Taylor & Francis Group, 2009, pp. 299–315.

[20] M. Boekaerts, "Self-regulated learning: Where we are today," *Int. J. Educ. Res.*, vol. 31, no. 6, pp. 445–457, Jan. 1999, doi: 10.1016/s0883-0355(99)00014-2.

[21] P. H. Winne and A. F. Hadwin, "Studying as self-regulated learning," in *Metacognition in Educational Theory and Practice*. Mahwah, NJ, USA: Lawrence Erlbaum Associates, 1998, pp. 277–304.

[22] D. H. Schunk, "Self-regulated learning: The educational legacy of Paul R. Pintrich," *Educ. Psychol.*, vol. 40, no. 2, pp. 85–94, 2005, doi: 10.1207/s15326985ep4002_3.

[23] A. Efklides, "Metacognition and affect: What can metacognitive experiences tell us about the learning process?" *Educ. Res. Rev.*, vol. 1, no. 1, pp. 3–14, Jan. 2006, doi: 10.1016/j.edurev.2005.11.001.

[24] S. Järvelä, M. Miller, and A. Hadwin, "Self-regulation, co-regulation, and shared regulation in collaborative learning environments," in *Handbook of Self-Regulation of Learning and Performance*, 2nd ed. New York, NY, USA: Routledge/Taylor & Francis Group, 2018, pp. 83–106.

[25] E. Panadero, "A review of self-regulated learning: Six models and four directions for research," *Frontiers Psychol.*, vol. 8, pp. 1–28, Apr. 2017, doi: 10.3389/fpsyg.2017.00422.

[26] J. Cerón, S. Baldiris, J. Quintero, R. R. García, G. L. V. Saldarriaga, S. Graf, and L. D. L. Fuente Valentin, "Self-regulated learning in massive online open courses: A state-of-the-art review," *IEEE Access*, vol. 9, pp. 511–528, 2021, doi: 10.1109/ACCESS.2020.3045913.

[27] M. Alonso-Mencia, C. Alario-Hoyos, and C. Delgado-Kloos, "Chrome plug-in to support SRL in MOOCs," in *Digital Education: At the MOOC Crossroads Where the Interests of Academia and Business Converge* (Lecture Notes in Computer Science), M. Calise et al., Eds. Naples, Italy, 2019, pp. 3–12.

[28] P. R. Pintrich, "The role of motivation in promoting and sustaining self-regulated learning," *Int. J. Educ. Res.*, vol. 31, no. 6, pp. 459–470, Jan. 1999.

[29] A. Srivastava, S. Bhardwaj, and S. Saraswat, "SCRUM model for agile methodology," in *Proc. Int. Conf. Comput., Commun. Autom. (ICCCA)*, May 2017, pp. 864–869, doi: 10.1109/CCAA.2017.8229928.

[30] R. Perez-Alvarez, J. Maldonado-Mahauad, D. Sapunar-Opazo, and M. Perez-Sanagustin, "NoteMyProgress: Supporting learners' self-regulated strategies in MOOCs," in *Data Driven Approaches in Digital Education*. Berlin, Germany: Springerm 10474, pp. 460–466, 2017, doi: 10.1007/978-3-319-66610-5_53.

[31] D. F. O. Onah and J. E. Sinclair, "Assessing self-regulation of learning dimensions in a stand-alone MOOC platform," *Int. J. Eng. Pedagogy (iJEP)*, vol. 7, no. 2, p. 4, May 2017, doi: 10.3991/ijep.v7i2.6511.

[32] T. Robal, Y. Zhao, C. Lofi, and C. Hauff, "IntelliEye: Enhancing MOOC learners' video watching experience through real-time attention tracking tarmo," in *Proc. 29th Hypertext Social Media*, 2018, pp. 106–114, doi: 10.1145/3209542.3209547.

[33] G. Sambe, F. Bouchet, and J.-M. Labat, "Towards a conceptual framework to scaffold self-regulation in a MOOC," in *Innovation and Interdisciplinary Solutions for Underserved Areas* (Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering), vol. 249, C. M. F. Kebe, A. Gueye, and A. Ndiaye, Eds. Cham, Switzerland: Springer, 2018, pp. 245–256, doi: 10.1007/978-3-319-72965-7_23.

[34] S.-Y. Hsu, Y. K. Chang, and V. Shaw, "Self-regulated learning user interface (SRLUI) design principles and experimental findings in MOOCs," *Educ. Innov. Emerg. Technol.*, vol. 2, no. 1, pp. 1–16, Mar. 2022, doi: 10.35745/eiet2022v02.01.0001.

[35] M. E. Alonso-Mencía, C. Alario-Hoyos, J. Maldonado-Mahauad, I. Estévez-Ayres, M. Pérez-Sanagustín, and C. Delgado Kloos, "Self-regulated learning in MOOCs: Lessons learned from a literature review," *Educ. Rev.*, vol. 72, no. 3, pp. 319–345, May 2020, doi: 10.1080/00131911.2019.1566208.

[36] D. F. O. Onah and J. E. Sinclair, "A multi-dimensional investigation of self-regulated learning in a blended classroom context: A case study on eLDa MOOC," in *Interactive Collaborative Learning*, vol. 545, M. E. Auer Michael and P. Guralnick, Eds. Springer, 2017, pp. 63–85, doi: 10.1007/978-3-319-50340-0_6.

[37] D. Davis, G. Chen, T. Van der Zee, C. Hauff, and G. J. Houben, "Retrieval practice and study planning in MOOCs: Exploring classroom-based self-regulated learning strategies at scale," in *Proc. Eur. Conf. Technol. Enhanced Learn.* (Lecture Notes in Computer Science), vol. 9891, 2016, pp. 57–71, doi: 10.1007/978-3-319-45153-4_5.

[38] M. Thirouard, O. Bernaert, L. Dhorne, S. Bianchi, and L. Pidol, "Learning by doing: Integrating a serious game in a MOOC to promote new skills," in *Proc. Eur. MOOC Stakehold. Summit*, 2015, pp. 92–96.

[39] C. Alario-Hoyos, I. Estévez-Ayres, M. Pérez-Sanagustín, D. Leony, and C. Delgado-Kloos, "MyLearningmentor: A mobile app to support learners participating in MOOCs," *J. Univers. Comput. Sci.*, vol. 21, no. 5, pp. 735–753, 2015.

[40] A. M. F. Yousef, M. A. Chatti, N. Danoyan, H. Thüs, and U. Schroeder, "Video-mapper: Una herramienta de anotación de video para apoyar el aprendizaje colaborativo en moocs," in *Proc. 3rd Eur. MOOCs Stakeholders Summit EMOOCs*, 2015, pp. 131–140.

[41] T. Unit and L. Innovation, "Recognising learner autonomy: Lessons and reflections from a joint X/C MOOC," in *Proc. HERDSA Conf.*, 2015, pp. 1–13. [Online]. Available: http://herdsa-2015.p.asnevents.com.au/days/2015-07-08/abstract/22639

[42] J. M. Marquez-Barja, G. Jourjon, A. Mikroyannidis, C. Tranoris, J. Domingue, and L. A. Dasilva, "FORGE: Enhancing elearning and research in ICT through remote experimentation," in *Proc. IEEE Global Eng. Educ. Conf.*, Apr. 2014, pp. 1–7, doi: 10.1109/educon.2014.7130485.

[43] F. Wang and M. J. Hannafin, "Technology-enhanced learning environments," *Educ. Technol. Res. Dev.*, vol. 53, no. 4, pp. 5–6, 2005.

[44] J. Cerón, S. Baldiris, and J. Quintero, "Methodology to support self-regulated learning in MOOC courses," Rev. virtual Univ. Católica del Norte, Tech. Rep. 71, pp. 50–80, Feb. 2024. [Online]. Available: https://doi.org/10.35575/rvucn.n71a4

[45] D. Calvo. (2018). *Metodología SCRUM (Metodologíaágil)*. Accessed: Feb. 26, 2020. [Online]. Available: http://www.diegocalvo.es/metodologia-scrum-metodologia-agil/

[46] Scriptcase. (2020). *Potente Plataforma RAD*. Accessed: Feb. 25, 2020. [Online]. Available: https://www.scriptcase.net/es/

[47] M. Rouse. (2015). *Guía Esencial: Las Bases De Datos Dan Soporte a Las Tendencias De TI*. Accessed: Feb. 26, 2020. [Online]. Available: https://searchdatacenter.techtarget.com/es/definicion/MySQL

[48] Sinemed. (2015). *Qué Es MySQL?* Accessed: Feb. 26, 2020. [Online]. Available: http://www.sinemed.com/recursos/docs/MySQL.pdf
[49] A. Wood. (2020). *HTML5 Basics For Everyone Tired Of Reading About Deprecated Code*. Accessed: Feb. 26, 2020. [Online]. Available: https://html.com/html5/
[50] J. Pérez-Jiménez. (2019). *Qué Es CSS3 Y Sus Fundamentos*. Accessed: Feb. 26, 2020. [Online]. Available: https://openwebinars.net/blog/que-es-css3/
[51] J. Márquez Díaz, L. Sampedro, and F. Vargas, "Instalación y configuración de apache, un servidor web gratis," Ing. y Desarro. Rev. la Div. Ing. la Univ. del Norte, Tech. Rep., 12, 2002.
[52] L. Barnard, W. Y. Lan, Y. M. To, V. O. Paton, and S.-L. Lai, "Measuring self-regulation in online and blended learning environments," *Internet Higher Educ.*, vol. 12, no. 1, pp. 1–6, Jan. 2009, doi: 10.1016/j.iheduc.2008.10.005.
[53] J. C. Nunnally, "An overview of psychological measurement," in *Clinical Diagnosis of Mental Disorders: A Handbook*, B. B. Wolman, Ed. Boston, MA, USA: Springer, 1978, pp. 97–146.
[54] R. Pérez-Alvarez, J. J. Maldonado-Mahauad, D. Sapunar-Opazo, and M. Pérez-Sanagustín, "NoteMyProgress: A tool to support learners' self-regulated learning strategies in MOOC environments," in *Proc. Eur. Conf. Technol. Enhanced Learn.* (Lecture Notes in Computer Science), vol. 10474, 2017, pp. 460–466, doi: 10.1007/978-3-319-66610-5_43.
[55] R. Pérez-Alvarez, J. Maldonado-Mahauad, and M. Pérez-Sanagustín, "Design of a tool to support self-regulated learning strategies in MOOCs," *J. Univers. Comput. Sci.*, vol. 24, no. 8, pp. 1090–1109, 2018.

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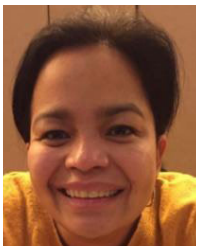

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