Tools For Collaborative Monitoring in Virtual Environments: A Systematic Review

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Abstract

Software tools for monitoring collaborative work in virtual LMS environments have become important in higher education, allowing to measure the level of collaboration and efficiency through interaction indicators during online work. The objective of this research is to perform an analysis of the existing software tools for monitoring collaborative work, detailing their characteristics, the monitoring process implemented, as well as the most used LMS platforms. In addition, the results grouped by criteria are synthesized for the type of monitoring with its type of visualization of results and the contributions provided by these tools from the student's point of view in terms of the criteria of self-regulation, participation and performance improvement; from the teacher's point of view as an aid for the control and monitoring of activities.

Keywords: Tracking Tools, CSCW, Higher Education, LMS, Metrics

Resumen

Las herramientas de software para el seguimiento de trabajo colaborativo en entornos virtuales LMS han tomado importancia en el ámbito de la educación superior permitiendo medir el nivel de colaboración y eficiencia a través de indicadores de interacción durante el trabajo en línea. El objetivo de esta investigación es realizar un análisis de las herramientas de software existentes para el seguimiento del trabajo colaborativo, detallando sus características, el proceso de seguimiento implementado, así como las plataformas LMS más utilizadas. Además, se sintetizan los resultados agrupados por criterios respecto al tipo de seguimiento con su tipo de visualización de resultados, y los aportes que brindan estas herramientas desde el punto de vista de los estudiantes en función de los criterios de autorregulación, participación y mejora de desempeño; desde el punto de vista docente como ayuda para el control y seguimiento de actividades.

Palabras clave: Herramientas de Seguimiento, CSCW, Educación Superior, LMS, Métricas.

1 Introduction

Collaborative work in virtual classrooms is an approach to shared stakeholder participation in online higher education. However, despite its importance and popularity, several questions about its use and effectiveness remain unresolved. In addition, online education faces problems of collaborative work tracking among students and even teachers. Thus, technological aspects acquire great importance in structuring online collaboration.

Digital tools support the technological perspective in the design of the online collaborative learning environment, being Virtual Learning Environments (VLE), a widely used computer resource in the context of teaching, mainly in higher education, in order to facilitate interaction between teachers and students (Costa *et al*., 2017).

Through these tools available on the internet, it is possible to access a course, subject or discipline in which teachers can interact with their students virtually, as well as monitor that in many of these environments, are pretty limited the participation in the teaching-learning process. Some of the most famous examples of VLEs are Moodle (Moodle.org 2018), Chamilo (Anon 2021) and Claroline (Pireva *et al*., 2015).

Within these virtual environments are the LMS tools, which, through metrics and indicators, make it possible to monitor online collaborative work. (Bradley 2020) tools, which through metrics and indicators, it is possible to monitor online collaborative work. This paper focuses on studying the LMS tools currently relevant in the higher education environment and the control and monitoring mechanisms they have.

This article is organized as follows: section 2 presents the methodology applied, followed by the research results in section 3. Section 4 discusses the results of the various tools and, finally, Section 5 presents the conclusions and future work.

2 Methodology

For the development of this work, a protocol has been proposed for the systematic review of the existing information so far that allows the identification of the available collaborative tools of the LMS type. Systematic review (SR) is a type of scientific research whose objective is to identify, evaluate and synthesize all relevant studies on a given topic (Boote and Beile 2017). The stages of SR are shown in Figure 1.

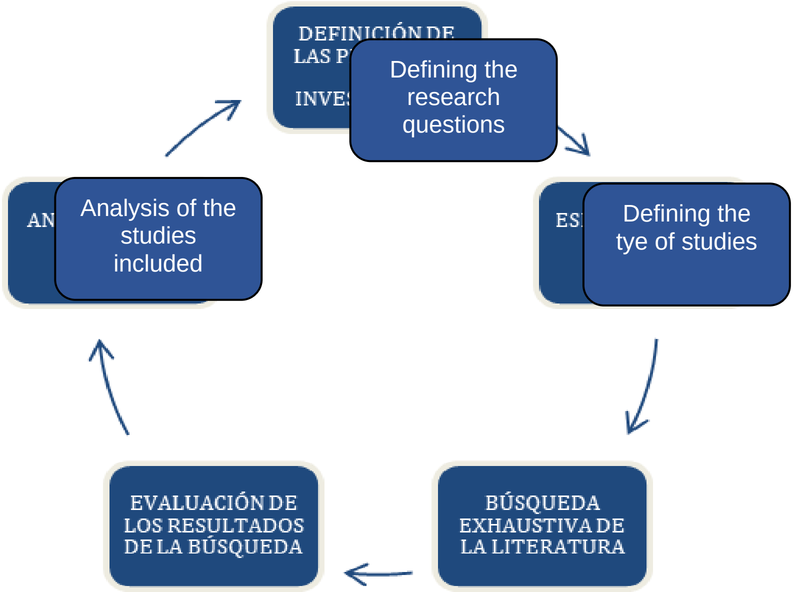

Figure. 1. *Stages of SR*

Following the methodology phases, the following research questions were posed, which will be answered in the development of this research.

1. What are the collaborative work tracking software tools?
2. What are the features of collaborative work tracking software tools?
3. What are the contributions of collaborative work tracking software tools?

The types of studies consulted and analyzed that made it possible to answer the research questions posed correspond to documents written in English and Spanish, prioritizing the literature in English.

In addition, those published in peer-reviewed scientific journals, conferences and congresses were considered, with publication or acceptance dates between January 2015 and 2021.

In order to discriminate the information consulted, the inclusion and exclusion criteria considered for the information analysis are specified in Table 1.

Table 1. *Inclusion and Exclusion Criteria*

Inclusion	Exclusion
1. Empirical studies that investigate software tools for monitoring collaborative work in higher education. 2. Empirical studies consider software tools for monitoring collaborative work in Higher Education as a population of interest.	1. Empirical studies that do not investigate work with software tools for monitoring collaborative work on the population of interest. 2. Studies address software tools for monitoring collaborative work with a reflective or theoretical approach. 3. Empirical studies investigate software tools' use for monitoring collaborative work in higher education but do not analyze collaborative activities. 4. Studies do not contain full text.

Once the characteristics of the articles to be included or excluded were established, the databases and search strings were selected to carry out the bibliographic research corresponding to stage 3 of the systematic review. As part of the search strategy, databases, digital libraries and journal portals were selected, such as ACM Digital Library, IEEE Xplore Digital Library, Scientific Electronic Library Online (ScieLO), Scopus, ScienceDirect.

Table 2 summarizes the terms in Spanish and English applied for the searches in the databases, libraries and journal portals mentioned above. It is important to note that both the keywords and the search strings were adjusted and modified according to the number of results obtained in each test.

Table 2. *Terms and keywords used in search strategies*

	Spanish	English
A1	Virtual Learning Environments (VLE)	Virtual Learning Environment
A2	Collaborative work follow-up	Follow up/tracking collaborative work
	Monitoring tool	Monitoring tool
A4	LMS Tools	LMS tool
A5	Collaborative activities	Collaborative activities
A6	Higher Education	Higher Education
A7	University	University

The strings that returned results in the searches of each scientific base and the number of results obtained in each of them are presented in Table 3.

Table 3. *Results obtained with search strings*

	Magazine	Search string	Results obtained
1	ACM Digital Library	[virtual learning environment] AND [LMS tool] AND [[tracking] OR [follow-up]]] AND [[higher education] OR [university]]] AND [monitoring tool] AND [collaborative activities] AND [Publication Date: Past 5 years].	857
	IEEE Xplore Digital Library	(Virtual Learning Environment) AND (LMS tool) AND (Tracking) AND (Follow up) AND (Higher Education) AND (University) AND (Monitoring tool) AND (Collaborative Activities)	212
	Scientific Electronic Library Online (ScieLO)	(Virtual Learning Environments) AND LMS AND Monitoring AND Collaborative Activities AND Universities AND Higher Education	0
	Scopus, ScienceDirect.	Virtual Learning Environment AND LMS tool AND (Tracking OR Follow-up) AND (Higher Education OR University) AND Monitoring tool AND Collaborative Activities	179

3 Search Results

3.1 Analysis and selection process

The results of the searches performed were 1248, after which the method of including and excluding according to the established criteria was applied, obtaining as a final result 13 articles included; Figure 2 shows the selection process.

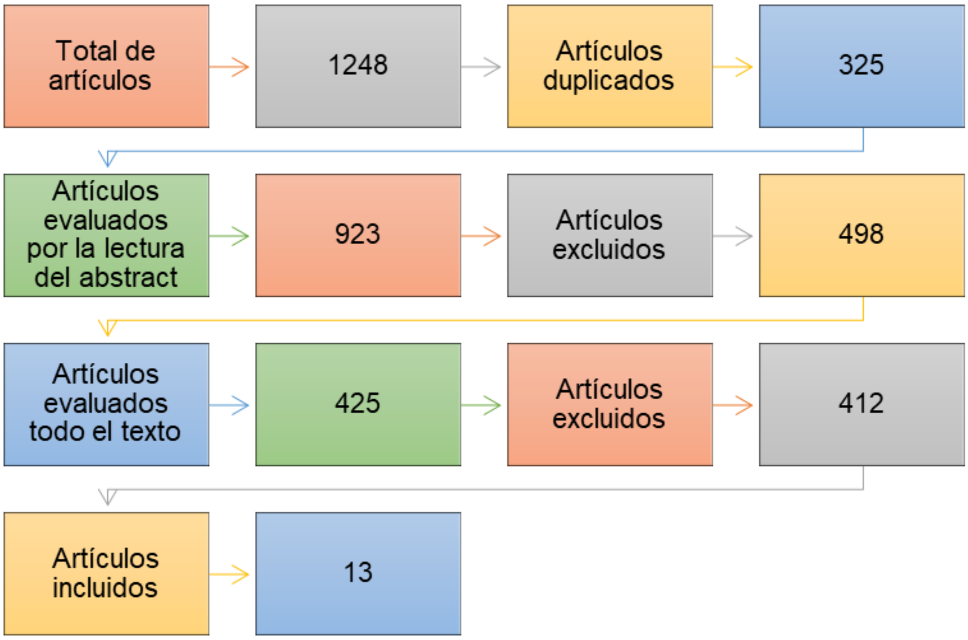

Figure 2. *Included and excluded items*

Figure 3 shows the percentage of the results of the articles selected by each of the databases consulted, being for ACM 45%, SCOPUS 39% and IEEE 15%, and in other sources such as ScieLO, no results were obtained in English or Spanish.

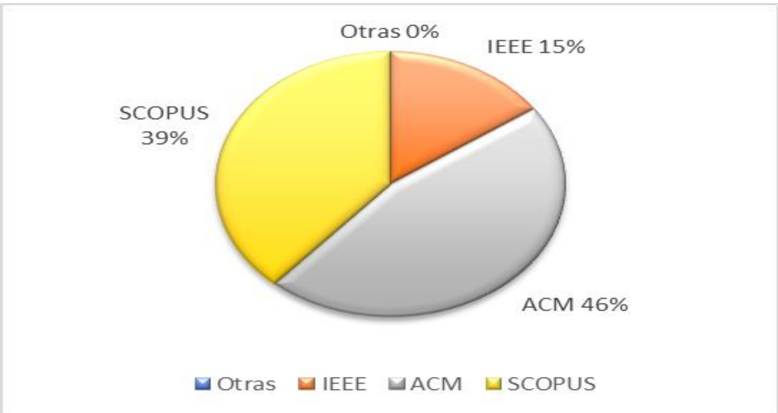

Fig. 3. *Search results by databases*

Table 4 summarizes the most relevant publications of the search specifying the database consulted; the LMS tool is analyzed with its description, where it can be seen that the Moodle tool is the one that has been most used for the implementation of control and monitoring mechanisms for collaborative activities.

Table 4. *Relevant publications from the search*

	Authors	Database	LMS tool	Description
1	Hirose (2016)	IEEE	Adaptive system for testing in universities.	Assessment systems based on Learning Check Tests (LCT) with Test Tracking Program (FPT) and Collaborative Test Work (CWT).
	Echeverria et al. (2016)	IEEE	Moodle	Learning analytics manager for collaborative learning activity tracking processes and student motivation in the Moodle learning management system.
	Pinto-Llorente et al. (2016)	ACM	Moodle (Wikis and forums)	Exploring college students' perceptions of wiki- and forum-based assignments as learning strategies to improve their writing skills and promote collaborative autonomy.
	Chow et al. (2018)	SCOPUS	Blackboard and Moodle	Evaluation of the effect of training on LMS use by Rasch analysis of activity logs of LMS use by teachers, making comparisons between teachers who have attended training and those who have not.
5	Yanacón-Atía et al. (2017)	ACM	Moodle	Moodle module for communication, coordination and collaboration, which captures and analyzes student interactions, generating indicators that show the degree of manifestation of their collaborative skills, at individual and group level.
	Kuosa et al (2016)	ACM	Moodle	Tool for analyzing student activity from automatically logged user data and interactive visualizations
	Hussain et al. (2018)	ACM	Moodle	Application of tracking student activities, as well as predicting underperforming students, is an important task because it allows instructors to reward students when their activity level deviates from normal activity levels as well as having lower grades.
	Gonzalez (2017)	ACM	Moodle (WIKI)	Proposal oriented to a collaborative work environment through the use of the Wiki tool.
	Hu et al (2017)	ACM	Moodle (Dashboard)	Cross-platform learning analytics dashboard in Moodle and Open edX to monitor learning progress based on outcomes.

Zhu, et al. (2019)	SCOPUS	Teaching Teamwork	Transition rate, entropy and sequential pattern mining analysis via chat message of two-year college students who worked on Ohm's Law related tasks in a simulation-based collaborative-indagitatorial learning environment.
Yeonjeon, et al. (2016)	SCOPUS	Moodle	Data-driven study using a latent class analysis method as a clustering approach for educational data.
Ji Won You (2016)	SCOPUS	Blackboard and Moodle	Study for the identification of meaningful behavioral indicators of learning using the learning management system (LMS) on online course performance.
Libor Juhaňáka (2019)	SCOPUS	Moodle (Quiz)	Exploration of student behavior and interaction patterns in different types of online quiz-based activities within learning management systems (LMS).

The characteristics of the collaborative monitoring tools in virtual environments that support the analysis carried out for the research where it favors the mastery of knowledge based on the selected articles for further substantiation of the importance of the topic under review are presented in Table 5.

3.2 Analysis of results

For the analysis of the results, it was decided to group the criteria into two categories: Monitoring tools and Contributions of the monitoring tools. Therefore, the evaluation criteria are presented and described below:

1) Collaborative work tracking tool.
   a. Type of monitoring. Three types of monitoring are considered for this criterion: activities, evaluation and resources.
   b. Type of follow-up visualization. This criterion focuses on identifying how visibility is given to the follow-up of the collaborative work. Four categories are considered: timeline, histogram, bar chart and pie chart.
2) Contributions of the tools
   a. Student. It refers to the contributions from the students' point of view in the use of monitoring tools. For this criterion, 3 types of contributions are considered: self-regulation, participation and performance improvement.
   b. Teacher. This refers to the contributions from the teachers' point of view in using the monitoring tools. Three types of contributions are considered for this criterion: control of activities, help in monitoring activities, and help decision-making.

Table 5. *Characteristics of monitoring tolos*

	Article title	Collaborative tool features	Tracking method	Description of the monitoring method
1	Meticulous Learning Follow-up Systems for Undergraduate Students Using the Online Item Response Theory	Online test systems based on Learning Check Tests (LCT) and Collaborative Test Work (CWT).	Test Tracking Program (FPT).	The TBI selects members for follow-up program (FP) classes automatically. Then, the FPT determines extracts members who will not attend the FP.
	Using a Learning Analytics Manager for monitoring of the collaborative learning activities and students' motivation into the Moodle system	Learning Analytics Manager: Motivation Booster. Service embedded in the Moodle System.	Working model of the OAG	1. Extraction: allows obtaining information on collaborative learning activities and motivational messages from the Motivation Manager data model. 2. Analysis: the related variables are shown through three types of graphical techniques: bar, linear and radar. 3. Visualization: The analyzed information is displayed in the OAG graphical user interface integrated to the Motivation Manager.
	How Wiki-based Tasks, and Forums Favor University Students' Writing Skills and Promote Collaborative Autonomy	Moodle tool: homework and forum as learning strategies to improve their writing skills and promote collaborative autonomy, as well as wiki-based methods.	Ex-post-facto quantitative analysis non-experimental design: SPSS version 24.	A pretest and posttest were used to operationalize the variables and collect the data for the study.
	Comparing trained and untrained teachers on their use of LMS tools using the Rasch analysis	Moodle tools: Content, Grade Center, Groups, Announcement, Assignments, Assignment, Message, Discussion Board, Email, Collaboration, Turnitin, Assessment, Wikis, Journals or blogs, Assessment tools (rubrics, self- and peer-assessment, browser or test lock, survey and group).	Analysis of Rasch - Winsteps version 3.92	1. Measure the results of the training to assess the effect of LMS training from teachers' LMS usage activity records by making comparisons between teachers who have attended the training and those who have not. 2. Each user action leaves information that is stored in the database tables as one or more records. 3. The LMS database was merged and stored in a new database. 4. The number of clicks were evaluated with respect to LMS activity.

5	Detecting Collaboration Skills to calculate Indicators in Moodle	New Moodle Chat Module for communication, coordination and collaboration, which captures and analyzes student interactions, generating indicators that show the degree of manifestation of their collaboration skills, at individual and group level: User queries, Message management, Work order management and Indicator management.	Moodle analysis tool of the Chat and Survey module	1. Access to the indicators automatically calculated by the developed module, consulting the number of interactions registered by the students and collaboration indicators, both individual and group. 2. Certain alternative filters were applied (by date, by collaboration-skill, by sub-skill or by collaboration attribute).
	Interactive Visualization Tools to Improve Learning and Teaching in Online Learning Environments	Tools developed as add-ons for Moodle LMS. Interactive visualization for learning management systems that analyzes student activity from automatically registered user data and creates visualizations providing valuable information about the learning process and student participation in a course offered to teachers and students. Tool that extends the navigation and search functionalities in the discussion forum of an LMS with a topic-driven paradigm by analyzing the forum content and automatically identifying discussion and topics. Enhancement of the original forum tool with a topic-based navigation structure and interactive interface.	TUT LA Tool	1. Data visualization pipeline in which user interaction is applied in data filtering and visual transformations 2. Data preprocessing: Raw log data representing user activity in the LMS is collected and analyzed. It is then enriched with different data sources describing users and content artifacts. Integrated into the data collection process, context definition is added to define what types and what parts of the data are collected. 3. Filtering and grouping: the prepared data are configured and grouped for selection. Scales and thresholds are defined according to the data. This step is revisited when users choose filters within the visualization system. 4. Visual mapping: configuration data are transformed into visual structures.
	Mining Moodle Data to Detect the Inactive and Low-performance Students during the Moodle Course	Learn Moodle Anonymized database. Tools used: discussion forums, quizzes, workshop and complete events during the course.	FURIA	Classification and clustering techniques to extract the pattern of student data during Moodle course completion. K-means grouping allows grouping inactive and active users and poorly performing users.

Collaborative work with wikis. Analysis of some innovative educational Centers	Moodle-Wiki: Learning environment linked to social construction approaches, facilitating the development of online collaborative work projects.	Moodle - Survey	The application of the survey is carried out after the development of a formative activity using the wiki in groups of 5 to 7 students. The survey is available online for 15 days, so that students can respond to it at the time they considered most appropriate.
An Outcome-based Dashboard for Moodle and Open EdX	Model-View Controller (MVC), allows visualizations, while the controller requests data from the server using AJAX and feeds the data to the view. The server side is responsible for the statistical calculation based on user activities registered in Moodle.	Open EdX	XBlock, a fundamental component to build XAct, which is implemented as one of Moodle's custom XBlocks that can get data from the edX database and transfer it to analyze the client's results through AJAX. Through views generated with the D3 library, XAct helps students verify their own online learning behaviors in near real-time.
Uncovering the sequential patterns in transformative and non-transformative discourse during collaborative inquiry learning	Teaching Teamwork: Collaborative inquiry learning environment featuring a series of STEM (science, technology, engineering and math) activities. Chat tool as a means of communication for students.	CSCiL	Tool that combines inquiry-based learning and computer-assisted collaborative learning. Entropy analysis and sequential pattern mining.
Clustering blended learning courses by online behavior data case study in a Korean higher education institute	Moodle features: learning profiles and materials, assignment submission, online quizzes/quizzes, discussion boards, chat tools and file repositories. Multiple course management, discussion forums and resources, project-based instruction and collaborative learning.	2-Phase Systemic Analysis: Mplus Version 6	Phase 1: Course research to explore the level and patterns of online activity. Phase 2: Specification of inclusion and exclusion criteria. Instructional interventions were conducted using Latent Class Analysis (LCA) in Mplus Version 6. LCA is a statistical technique for multivariate categorical data to identify common patterns among a set of variables to classify the individual unit of analysis into unobserved subgroups.
Identifying significant indicators using LMS data to predict course achievement in online learning	Blackboard and Moodle, provide analytical functions or summary reports to instructors and track LMS usage data, which allows to tangibly capture students' self-regulated behaviors.	Moodle and Blackboard analytical functions.	Verify the number of accesses to the platform, compliance of activities in the established time, material downloading, among others.

Using process mining to analyze students' quiz-taking behavior patterns in a learning management system	Moodle: Questionnaire tool, event logging system, which collects event-based data on student and teacher behavior within the system.	Disco Miner (Fuzzy Miner Algorithm)	Process mining to identify behavioral patterns.

Table 6 synthesizes research on software tools for monitoring collaborative work in virtual environments. From the systematic review conducted to a set of studies of which thirteen articles were considered as included and as part of the research, it was evidenced that more than five articles focus the collaborative work tracking tools to activities (Echeverria *et al*., 2016), *(Pinto-Llorente et al*., 2016), (Yanacón-Atía *et al*., 2017)., (KuosaKirsi *et al*., 2016), (Hussain *et al*., 2018), (Zhu *et al*., 2019), (Park *et al*., 2016), (You, 2016) and (Juhaňák *et al*., 2019), regarding the type of visualization that presents how the tracking is given, 54% of the articles use bar charts to project collaborative work participation.

The contributions brought by the software tools are several, among which is that the student acquires the ability to self-regulate based on the acquisition that arises from the autonomy of collaborative work. Furthermore, the improvement of participation and performance are positively affected by the dynamics with which the tools influence learning development. The teacher, who is a guide for his students, realizes how the monitoring tools favor the control of the activities, strengthen the follow-up, and help in the correct decision making.

Table 6. *Analysis of relevant publications*

			1				**5**								
Collaborative work tracking tool	**Type of monitoring**	Activities		x	x	x	x	x	x	x		x	x	x	x
		Evaluation	x			x									
		Resources				x					x				
	Type of display	Timeline													
		Histogram	x			x		x	x						x
		Bar graph		x				x	x	x	x	x	x		
Contributions of the tools	**Student**	Self-regulation						x			x			x	
		Participation	x	x	x	x	x		x	x	x	x	x		
		Performance improvement.	x	x	x	x		x	x		x	x	x	x	x
	Teacher	Control of activities		x			x	x			x		x		x
		Assistance in monitoring activities	x	x		x	x	x			x	x	x	x	
		Decision support		x		x	x	x	x	x	x	x		x	x

4 Discussion And Results

The monitoring of collaborative work in virtual learning environments is a fundamental need for teachers and researchers in the area, making it a challenge to constantly study the behavior of students within the learning management systems (LMS), is a topic of great interest since technology has occupied a large percentage of the areas of knowledge and labor sectors. Hence, it is very important to monitor exactly what happens in online courses, how students behave on digital platforms, how they approach online study materials or how they work when performing collaborative activities among students on digital education platforms. That leads to paying more attention to monitoring and visualization types that can be optimally offered to participants in collaborative work and require knowledge of how they perform in groups.

According to the results achieved in the systematic review developed in this research, the software tools to strengthen the monitoring of collaborative work currently favor students in the self-regulation of their performance and knowledge acquisition and promote active participation; it favors the teacher to maintain control of the activities performed, support the monitoring of activities and in turn strengthens the decision making on different aspects that a teacher has to evaluate his group of students.

Studies such as that of the authors Juhan et al. (2019) expose in their exploratory section the monitoring method Disco Miner (Fuzzy Miner Algorithm), which is used within the LMS Moodle based on the use of questionnaires to identify and analyze the behavior that students acquire within this learning management system. It focuses on the great relevance of process mining, which has had its greatest boom in the business sector, and that in recent years has had a great opening in the educational field since this monitoring method provides encouraging expectations about test taking in LMS, providing a complete analysis on how students interact in the completion of questionnaires, allowing mapping and modeling the process involved to terminate the questionnaires (exams) among the types of behaviors that are modeled, for example: guessing behavior, sleeping behavior, “gaming the system,” help-seeking, willingness to collaborate, among others.

Another study by Hirose (2016) presents as a collaborative monitoring tool the test systems, which consist of LCT as an evaluation system based on learning verification tests, FPT as a test-based monitoring program and CWT as a collaborative work based on tests. These systems are focused on tracking online evaluations, where the type of visualization presented is through histograms, where the estimate of the capacity acquired within the response process is represented.

These test systems are connected to a portfolio system that manages the scores and behaviors acquired by the students during the development of the online evaluations. The advantage acquired by the students is to improve their participation to dynamically develop the questions, while achieving an optimal performance in realizing these. At the same time, the teacher acquires the ability to visualize the follow-up of the activities and thus strengthen the teacher’s position as a guide to guide those who continue to relapse in obtaining unfavorable grades. However, at the same time, encourage strategies so that students continue to collaborate to acquire successful results with the help of agile software tools.

On the other hand, in the research presented by the authors Echeverria, Benítez, Buendía, Cobos and Morales (2016) present as a collaborative learning analytics Manager tool: Motivation Booster, which is a functionality integrated into the Moodle system, to evaluate the monitoring of collaborative learning activities and student motivation within Moodle. It uses the GAA learning analytics manager work method, which requires two approaches for its implementation: AAAC analysis of collaborative learning activities and AMM analysis of motivational messages.

This GAA working model requires three interconnected processes: extracting relevant information about collaborative learning activities and motivational messages. First, analysis of the variables of the two mentioned approaches is presented in bar, linear and radar graphs. Visualization in the graphical user interface of the detail of the GAA model. Acquiring as promising advantages that students improve their activity in participation and performance as a strengthening of the learning process; it allowed the teacher to diagnose who required more support in collaborative work, also to achieve adequate control of the activities proposed in Moodle and how was the performance of students with each resource or activity proposed. This allowed the teacher to acquire a better vision for correct decision-making.

In this regard, the authors Pinto-Llorente, Sánchez-Gómez, García-Peñalvo and Cabezas-González (2016) present the Moodle tool focused on wikis and forums activities as a strategy to strengthen written skills obtaining as a benefit a collaborative autonomy, the results of the study show that the student acquires greater participation and better performance. Furthermore, the scheffe posthoc test revealed the efficacy of the mentioned activities for the construction of autonomous knowledge.

Authors such as Chow *et al*. (2018), Yanacón-Atía *et al*.(2017) and KuosaKirsi *et al*. (2016) focus their tracking methods on Moodle tool activities: content, grade center, groups, announcement, assignments, assignment, message, discussion board, email, collaboration, turnitin, assessment, wikis, journals or blogs, assessment tools including rubrics, self-assessment and peer assessment, browser lock or test, survey and group). In order to perpetuate accurate visualizations using histograms or bar graphs, the extent to which students provide data in each of the Moodle tools when working collaboratively is reflected. The author Yanacón-Atía directs his study focus to a new chat module for students to analyze their interactions and the quality with which the members contribute, thus favoring students to improve their participation and self-regulation. At the same time, the teacher can control the activities to make a correct follow-up for the correct decision-making.

Software tools to support collaborative work monitoring are strongly associated with current virtual learning environments where bar charts and histograms prevail, authors such as Hussain *et al*. (2018), Rodero (2017), Hu *et al*. (2017), Zhu *et al*. (2019) and Park *et al*. (2016) direct their research studies to Moodle activities such as chat, survey, wiki, forum, which build a social link in the construction of knowledge in such a way that facilitates the development of collaborative work, to the extent that confidence in self-training and feedback among group mates arises. Where participation presents a remarkable increase among the understanding of the factors or variables involved in the tasks in such a way that the members ensure a shared understanding and improvement in performance. Teachers ensure control of activities and accurate decision-making.

In order to address the first research question, a set of 13 collaborative work tracking software tools Hirose (2016), Echeverria *et al*. (2016), Pinto-Llorente *et al*. (2016), Chow *et al*. (2018), Yanacón-Atía *et al*. (2017), KuosaKirsi *et al*. (2016), Hussain *et al*. (2018), Rodero (2017), Hu *et al*. (2017), Zhu *et al*. (2019), Park *et al*. (2016), You (2016) and Juhaňák *et al*. (2019).

To answer the second research question, in terms of the characteristics found, the LCT, FPT and CWT Systems are based on evaluation systems with tests to verify learning and collaborative work, using the test tracking program. The analytical learning manager with a complement to motivation is characterized as an embedded service of the Moodle system, improves participation and performance; the improvement in writing characterizes Moodle tools such as assignments and forums, development of skills and promotes autonomy in the collaborative process. New Chat Module, as a complement to Moodle, its functionality and feature lie in the improvement of communication, coordination and collaboration, which is captured and the interactions between students are analyzed to generate indicators that visualize the degree of collaborative skills. Finally, the Moodle System for KuosaKirsi *et al*. (2016) characteristic is reflected in the analysis of the activities developed by students with data from automatically registered users and, in turn, builds interactive visualizations.

Tut La Tool adopts an analysis approach with visual perspective in order to discover the activity that students perform and their participation by channeling data visualization. Fury is based on classification techniques and for the extraction of student data schema during a Moodle course; Moodle-Survey reflects its characteristic in a learning environment linked to the use of the wiki with a social constructivist approach where the development of online collaborative projects are facilitated as a formative activity; MVC (Model-View Controller) its functionality emphasizes on obtaining data from the EdX database which, analyzed through AJAX, promotes views with the help of the D3 library, allowing students to visualize their behavior and learning progress online; presents Teaching Teamwork chat tool with CSCiL as a monitoring method is characterized by the combination of inquiry learning and computer-assisted collaborative learning, which presents a series of STEM activities. Finally, moodle-Quiz with Disco Miner is a monitoring method characterized by process mining in the implementation and development of various types of questionnaires where it collects behavioral data from students and teachers within the platform. To answer the third research question, among the contributions, 85% of the software tools identified for monitoring collaborative work in virtual environments improve student performance, where 77% of these tools improve active participation, and 23% motivate self-regulation; While for teachers, it is reflected that 46% of the tools allow adequate and supervised control of the activities, on the other hand, 69% of the tools strengthen the monitoring of activities and finally 77% allow teachers to make accurate decisions based on the performance and behavior of students in virtual learning environments performing collaborative activities.

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