

A Systematic Review of Teacher-Facing Dashboards for Collaborative Learning Activities and Tools in Online Higher Education

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Abstract

Dashboard for online higher education support monitoring and evaluation of students' interactions, but mostly limited to interaction occurring within learning management systems. In this study, we sought to find which collaborative learning activities and tools in online higher education are included in teaching dashboards. By following Kitchenham's procedure for systematic reviews, 36 papers were identified according to this focus and analysed. The results identify dashboards supporting collaborative tools, both synchronous and asynchronous, along categories such as learning management systems, communication tools, social media, computer programming code management platforms, project management platforms, and collaborative writing tools. Dashboard support was also found for collaborative activities, grouped under four categories of forum discussion activities, three categories of communication activities and four categories of collaborative editing/sharing activities, though most of the analysed dashboards only provide support for no more than two or three collaborative tools. This represents a need for further research on how to develop dashboards that combine data from a more diverse set of collaborative activities and tools.

2012 ACM Subject Classification Applied computing → Collaborative learning; Applied computing → Distance learning; Applied computing → E-learning

Keywords and phrases Dashboards, collaborative tools, collaborative activities, online learning, e-learning, computer-supported collaborative learning

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1 Introduction

Online learning has grown in public interest in the last few years, largely due to the COVID-19 pandemic [34]. A popular online pedagogical strategy is collaborative learning, where students interact with each other and in groups, typically seeking consensus on a learning topic [35].

Although monitoring students' online collaborative activities makes teaching more effective, as in face-to-face learning [45], and even though many collaborative tools have some kind of monitoring functionalities, most teachers and tutors are discouraged of doing so. The main reason for this is that such monitoring requires devoting substantial time and effort, as it is primarily a manual task [41].



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Learning dashboards support online teaching by automating the extraction and analysis of data on students' interactions within collaborative tools used in online learning. However, most collaborative activities dashboards are student-facing, to assist in students' self-regulation or help students' improve their own learning outcomes, unlike learning dashboards in general, which are mostly teacher-oriented [50].

To support teacher monitoring, and consequently support pedagogical orchestration, teacher-oriented dashboards for collaborative learning contexts need to consider students' interaction data, known as collaborative activities indicators [3]. These may include forum participation, sentiment analysis, document editing or audio-visual conferencing, among significant diversity of online collaborative learning activities [41]. Interaction data may be extracted both from synchronous or asynchronous tools, learning management systems (LMS), and as other pieces of software, such as communication or collaborative writing tools [1, 31]. In this study, we identify which collaborative tools and what collaborative activities are supported by indicators in current teacher-facing dashboards, in the context of online higher education.

To achieve this objective, we applied Kitchenham's procedure for systematic reviews to answer two research questions: RQ1: "Which collaborative tools are supported by online higher education teaching dashboards?" and RQ2: "What indicators about collaborative activities are provided in online higher education teaching dashboards?"

2 Background

2.1 Dashboards

A dashboard is "a visual display of the important information needed to achieve one or more goals, consolidated and arranged on a single screen" [54].

In educational contexts, these are typically known as Learning Dashboards, aggregating indicators about individual learners or groups, the learning processes, and the learning context, regardless of their target users being students (as with StepUp! [48] and STEMscopes [39]), teachers (with dashboards like GradeCraft [25], or GLASS [36]), program chairs (e.g. [19]; [57]), administrators (e.g. LADA dashboard [23]) or educational researchers (e.g. moocRP [50]). Learning dashboards aim to support decision-making by educational context participants, as well as support students' motivation and prevent dropout [33].

2.2 Collaborative Learning

Collaborative learning is defined as two or more people working together toward a shared learning goal [28], a context where "learners have the opportunity to converse with peers, present and defend ideas, exchange diverse beliefs, question other conceptual frameworks, and are actively engaged", including by editing or improving artefacts, either directly or indirectly [28].

Collaborative learning, within the context of online learning, involves collaborative tools, either synchronous or asynchronous. These may be communication tools, such as Discord (2015), Slack (2013), Skype (2003) or Zoom (2011), discussion tools like blogs or forums, collaborative writing tools such as Google Docs (2006), Microsoft Office 365 (2011) or Zoho (2005), social networking/media sharing tools including Facebook (2004), Twitter (2006), Youtube (2005) or Prezi (2009), source code management tools like Github (2008) or Gitlab (2011), project management tools such as Asana (2011) or Trello (2011), and learning management systems (LMS), e.g. Moodle (2002), Blackboard (1997) and Canvas (2011) [1, 31].

Collaborative learning activities are actions, tasks or exercises that enable collaborative learning, commonly grouped as synchronous, asynchronous or blended, and classified as discussion activities (with indicators such as sentiment analysis) involving forum participation, interaction, or rating, communication activities like instant messaging, audio-visual conferencing or emails and collaborative editing or development of activities such as document editing, programming code submission, file sharing or project management [3, 31].

Monitoring students online collaborative activities makes teaching more effective by checking their learning process, the access and review of learning resources or by keeping track of their contributions and their quality [45]. Often this is a manual task that involves substantial time and effort [41].

3 Research Methods

The goal of this systematic literature review is to identify which collaborative tools and activities are currently supported by indicators in online higher education teaching dashboards. The framework that we applied was Kitchenham's systematic reviewing procedures [32].

Kitchenham's procedures have three main phases: the planning of the review, where the need for the review is stated and the review protocol is developed; the research questions and strategy used to search primary studies, which includes the search query or terms, which databases or journals and conference proceedings to include, study selection criteria, study quality assessment and data extraction strategy; and conducting the review, where the search for the research studies is carried out, the studies quality assessment is performed and the data extraction and synthesis is executed.

In this systematic review our research questions are: RQ1: "Which collaborative tools are supported by online higher education teaching dashboards?" and RQ2: "What indicators about collaborative activities are provided in online higher education teaching dashboards?"

The Population of this systematic review, under Kitchenham's procedure for the planning stage, are online higher education teaching staff (professors, teaching assistants, etc.), the Intervention target are the learning dashboards, the Comparison criterium for inclusion is the dashboards' usage, and the Outcome items are dashboard indicators about students' collaborative activities and collaborative tools from which those indicators are collected. Finally, the Context is online higher education.

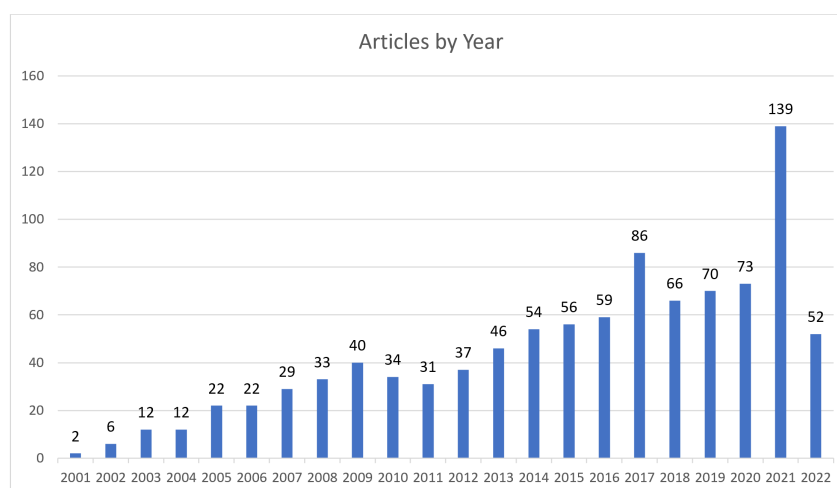
3.1 Selection Process

The search query used was a combination of the keywords "online learning", "dashboard", "collaborative tools", "activities indicators" and their synonyms. The search process was conducted with the Publish or Perish software (available from <https://harzing.com/resources/publish-or-perish>) [24] using Google Scholar's database to look for the search terms in articles' titles and keywords.

We chose Google Scholar for this search process since nearly all citations found in other databases like Web of Science and Scopus were also found in Google Scholar's database and also that a substantial amount of unique citations were not found in these other databases [38]. However, since Google Scholar also includes less reputable sources, this required close scrutiny for reliability during the exclusion process.

3.2 Exclusion Process

In the exclusion process, duplicated articles were excluded. Then, because of the rapid evolution associated with social media, instant messaging and online learning collaborative tools, we considered only articles from the most recent 10 years, considering they represent 71% of all found articles, as shown in Figure 1, and some of the most used collaborative application were only launched recently, such as Discord in 2015, Slack in 2013, and Teams in 2017.



■ **Figure 1** Articles identified from the selection process by year of publication.

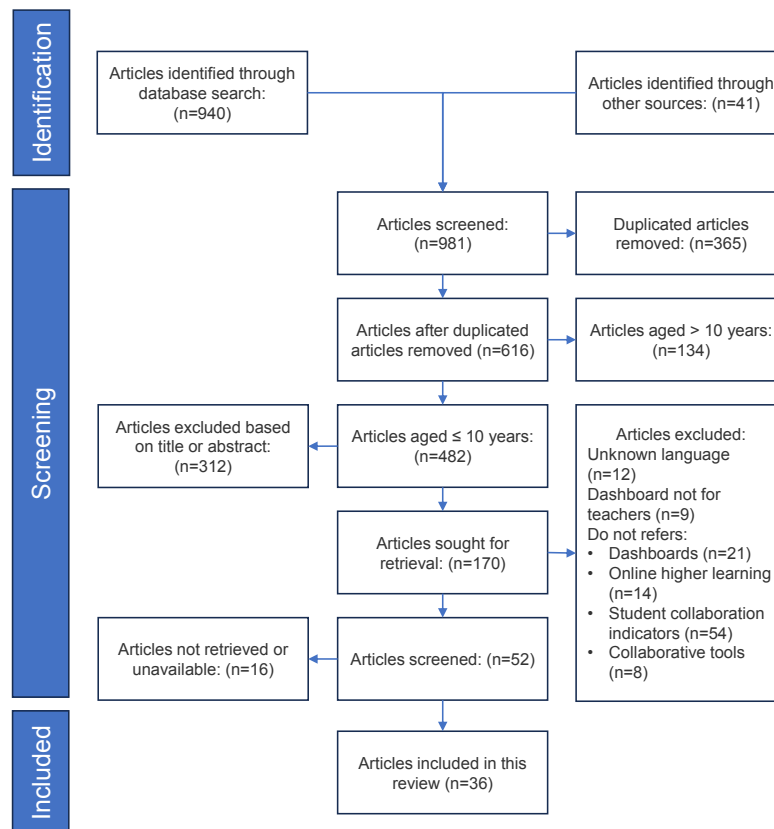
Afterwards, the titles and abstracts of the articles were analysed and those that were not relevant or did not make reference either to dashboards or to online higher education or to collaborative activities indicators were also excluded.

Finally, a more in-depth analysis was made by examining the entirety of the remaining articles. We excluded those not addressing teacher-facing dashboards (9 articles) or online higher education (14 articles), i.e. not meeting the the Population, Intervention or Context of this systematic review. We also excluded articles which did not mention collaborative platforms or indicators (62 articles).

As shown in Figure 2, a total of 981 articles were identified: 940 articles from the search queries and 41 from other serendipitous sources. From the selection process, 365 articles were found to be duplicates, 134 articles were more than 10 years old, 312 articles did not make reference either to dashboards, to online higher education or to collaborative activities indicators, based on the title or abstract. All these were excluded. There were 12 articles written in languages that the researchers are unable to read, i.e. neither in Portuguese, English, French, nor Spanish, and 122 articles that did not meet the selection criteria, resulting in 36 articles that were analysed for this systematic review (see Table 1).

4 Results and Discussion

As a result of the search process, both synchronous and asynchronous collaborative tools were used as analysis categories. These include communication tools, discussion tools, collaborative writing tools, social networking/media sharing tools, source code management tools, project management tools, and learning management systems [1, 31].



■ **Figure 2** Diagram of the systematic literary review.

We extracted elements from the final corpus of papers and subjected them to thematic content analysis, performing coding and theme development, leading to the following results.

Regarding RQ1, “Which collaborative tools are supported by online higher education teaching dashboards?” we found that the collaboration tools most used as data sources for online higher education teaching dashboards were learning management systems (and mainly Moodle), followed by social networking/media tools and collaborative writing tools (see Figure 3), appearing in 28 of the 36 articles.

The analysis categories utilised to achieve the second research question, RQ2: “What indicators about collaborative activities are provided in online higher education teaching dashboards?”, were collaborative learning activities such as discussion activities, communication activities and collaborative editing or development of activities [3, 31]. The discussion activities identified were forum participation, rating, and networking (mainly on LMS forums); the communication activities refer to synchronous communication, such as audio-visual conferencing, asynchronous communication (like email) or both synchronous and asynchronous communication using live chat or instant messaging by the use of tools like Slack or Discord.

The results regarding the collaborative activities’ indicators identified in the articles were mostly related to characterising LMS forum discussion activities, referenced in 31 articles of the total corpus, followed by indicators on live chat/instant messaging or other communication activities, and by indicators on collaborative editing or development of activities (see Figure 4).

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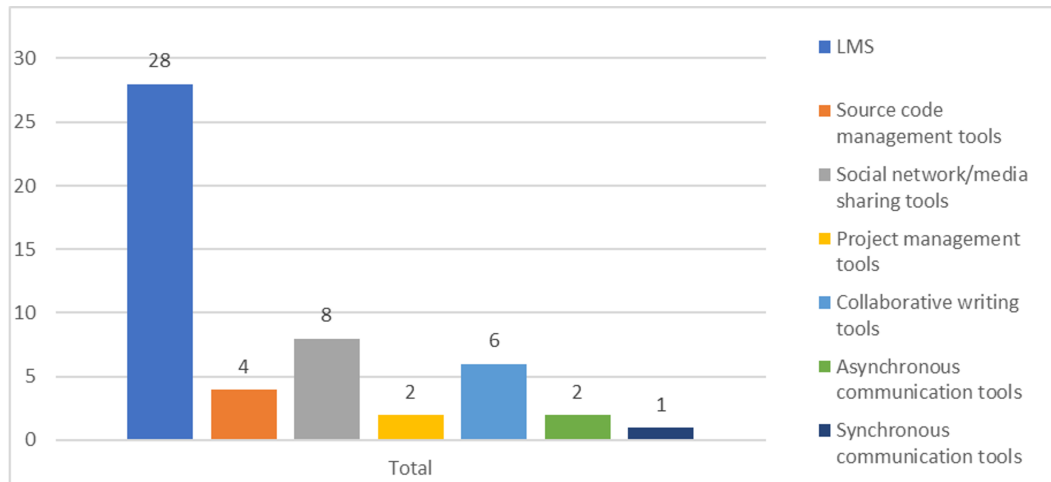
■ **Table 1** Overview of collaborative tools used in the dashboards from the reviewed articles.

Articles	LMS	Source code management tool	Social network/ media tools	Project management tools	Collaborative writing tool	Async. comm. tools	Sync. comm. tools
[2]	✓						
[4]	✓						
[5]	✓						
[6]	✓						
[7]	✓						
[8]	✓	✓	✓	✓	✓		
[9]	✓			✓			
[10]	✓						
[11]	✓		✓				✓
[12]	✓						
[13]	✓						
[15]	✓						
[16]	✓						
[17]	✓						
[18]		✓	✓	✓		✓	✓
[20]	✓						
[21]			✓				
[22]			✓				
[25]	✓						
[26]	✓						
[27]	✓						
[29]	✓						
[30]		✓					
[37]	✓						
[40]		✓					
[42]				✓		✓	✓
[43]		✓				✓	✓
[44]	✓	✓				✓	
[46]	✓	✓				✓	
[49]	✓	✓		✓	✓		
[51]	✓						
[14]		✓	✓				
[53]	✓						
[55]	✓						
[56]	✓						
[58]	✓						

Results on teaching dashboard indicators about collaborative activities in online higher education, were identified in the articles. These were mostly related to characterising LMS forum discussion activities, as referenced in 31 articles of the whole corpus of 36 articles. These provide relevant knowledge about student's interactions, namely by messages sentiment analysis and forum interaction networks. However, the asynchronous nature of forums does not provide the full dynamics of how students are communicating and collaborating with their peers. Particularly low in occurrences where indicators on project management, file sharing, submission of programming code, audio-video conferencing and email communication. Regarding this kind of collaborative learning indicators, we find there is a lack of research and possible future research is needed and encouraged. The least used collaborative tools as data sources in the teacher-facing learning dashboards were source code management tools, synchronous and asynchronous communication tools, and project management tools.

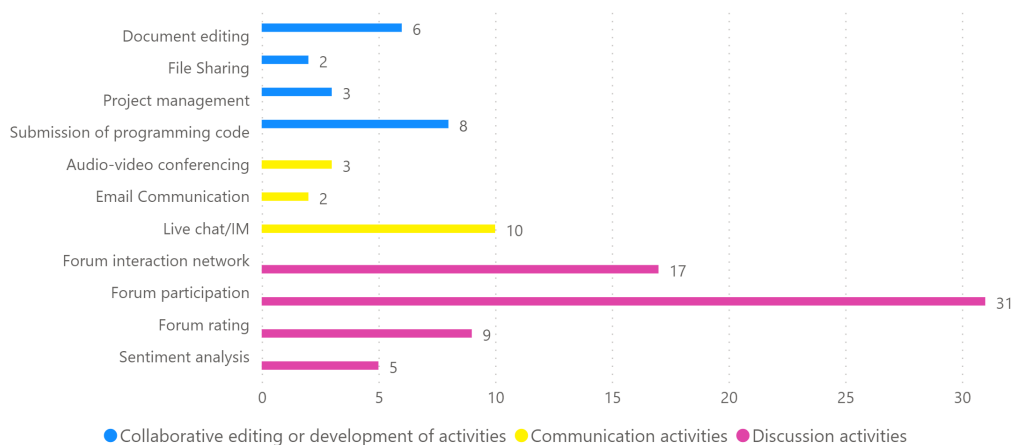
Regarding collaborative tools, most dashboards mainly used data from learning management systems exclusively and, to some extent, social network/media sharing tools or collaborative writing tools. By doing so, knowledge available from these dashboards is

somewhat restricted to the more strict or formal communication in the LMS and ignores other data sources, such as live chat/IM platforms or source code management tools. Thus, a more dynamic overview of the collaborating interaction between students is being ignored.



■ **Figure 3** Collaborative tools used in online higher education teacher-facing dashboards, by type.

In this systematic review, we identified a relationship between collaborative tools and collaborative activity indicators. The collaborative editing or development activities mostly take places in collaborative writing tools, project and source code managements tools, whereas discussion activities predominantly are carried out on the LMS. Regarding communications activities, email communication and live chat/IM, these take place in asynchronous communication tools, except for audio-video conferencing, which is synchronous in nature.



■ **Figure 4** Collaborative activities indicators identified in online higher education teaching dashboards.

5 Conclusions

In this study we identify which collaborative tools and activities are the source of indicators utilised in online higher education teaching dashboards.

The low occurrence of dashboard support for collaborative activities on asynchronous tools such as Slack or Discord is surprising, considering that none of the few indicators found in those categories used these collaboration tools as data sources, even though such collaboration tools are very popular among online higher education students, leveraging their social media-like features, and their combination of group and private messaging [47, 52]. A possible reason could be the pedagogical approach implemented in the institutions or a possible lack of knowledge or training on the part of the lecturers, something that was observed during the emergency online learning due to COVID-19 pandemic [45].

Additionally, several indicators on collaborative activities refer only to a single collaborative tool, notwithstanding that these indicators could be also implemented with data extracted from other data sources, in order to get a better understanding of student activity and interaction. An example of this is sentiment analysis, participation statistics, and interaction network indicators, which are mostly applied to LMS forum data, even though they could also use data from other collaborative tools, such as Slack or Discord, whereas live chat/IM communication activities indicators could also be applied to direct messages featured in most LMS.

We propose that future research efforts explore the challenges and opportunities of leveraging indicators about online collaborative learning activities taking place in the collaboration tools more frequently used in recent years, seeking to contribute to better understanding of collaborative learning in online contexts. This better understanding, in turn, is key to supporting better collaborative education and deploying collaborative learning.

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