

Learning Analytics to Support the Provision of Feedback in Higher Education: a Systematic Literature Review

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Abstract—The digital transformation in higher education (HE) makes it important for students to acquire self-regulated learning (SRL) skills. Timely feedback is considered a powerful means for developing these skills, and learning analytics (LA) is a promising approach for high-quality and scalable feedback. This paper presents a systematic literature review on LA feedback tools to improve SRL skills in HE hereby contributing to the understanding of the current state of the art and the identification of remaining existing gaps. After reviewing 31 articles, our results indicate that research on LA feedback tools to support SRL is relatively limited and these investigations often lack a solid theoretical basis in SRL. We also found that these LA feedback tools are mostly targeted to students, and that there is a limited evaluation of the impact of these LA feedback tools. This systematic literature review calls to action to perform empirical research for measuring the impact of these tools.

Index Terms—Feedback, Time Management, Learning analytics, Self-Regulation Learning, Higher Education ¹

I. INTRODUCTION

Students transitioning to Higher Education (HE) institutions encounter challenges in adapting to the new environment, learning and teaching approaches, etc. Timely support can strengthen students in the transition and thus be instrumental in succeeding in this new endeavor. It has been shown that a student's lack of motivation, commitment, and self-regulation skills may increase the risk of drop-out and dissatisfaction with the learning experience [1], which has been exacerbated by the COVID-19 pandemic [2]. Self-Regulated Learning (SRL) refers to the cognitive, metacognitive, and motivational factors and goals that students use to attain and accomplish their goals during the learning processes [3]. Research has found that SRL

strategies, such as goal setting, strategic planning, and time management, are associated with students' performance and attainment of goals [c.f., [4]]. Therefore, HE institutions must provide teaching and counseling strategies to foster students' SRL skills and thus improve their academic performance [1]. Empowering students with timely feedback about SRL strategies may lead to several benefits, such as increased student motivation and performance and a better learning experience [5]. Yet, scaling this provision of feedback is a complex and time-consuming task for different HE stakeholders (i.e., teachers, advisors, counselors) due to the various students' needs, technological, financial, and work-power challenges. Learning Analytics (LA) is a research area focused on implementing data-driven and scalable feedback solutions aimed at improving teaching and learning practices [5]. In this sense, LA may provide a pedagogical and technological solution to address the challenge of providing personalized feedback at-scale. There has been a great interest in fostering self-regulation (SRL) strategies through timely and personalized feedback to help students to succeed during their study programs [c.f., [5], [6]]. In a recent literature review, Matcha et. al. [7] reported the current research space of Learning Analytics Dashboards (LADs), which are considered a form of feedback, from an SRL perspective. Our work extends this prior work by exploring other types of feedback besides LADs. The literature reviews of Viberg et al. [8], focusing on empirical research on self-regulated learning and LA, and Pérez-Alvarez et. al. [6], examining the research space of EdTech tools to support SRL, both focused on online learning environments. Our work takes a wider scope and looks beyond online learning environments in the HE domain. To identify further research directions

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for designing and developing feedback tools to support SRL strategies, this literature review aims at understanding the current state of the research focusing on SRL, specifically in 1) theory or models for designing and developing feedback tools, 2) the feedback characteristics, 3) the feedback role connected to LA, 4) the feedback context and research methodology, and 5) the feedback evaluation and impact.

II. PRIOR WORK AND RESEARCH QUESTIONS

Matcha et al. [7] conducted a literature review to report the current state of the art on LADs, focused on assessing the impact from an SRL perspective. The authors pointed out that most empirical studies did not include any SRL theory or model for supporting the development of LADs indicators. They additionally reported that most LADs were poorly designed as they partially supported the SRL process, which might impact its adoption. Current LAD solutions are not well suited for effective feedback as they are not often actionable nor dialogical [9]. Viberg et al. [8] performed a literature review of empirical research on self-regulated learning and LA, specifically for online learning environments, using the lens of Zimmerman's SRL model [3]. They find that most research focuses on the forethought and performance phase and less on reflection; the lack of research evidence for the impact of LA on learning outcomes and improvements in learning support and teaching; and that LA is not widely used. In the literature review by Perez-Alvarez et al. [6], the authors reported a list of EdTech tools that support SRL in online environments, such as MOOCs. The results were aligned with Matcha et al. [7] by confirming a disconnection between the information collected or presented and SRL strategies and a lack of empirical evidence on the impact of these tools. The authors also indicated that only 4 out of 19 tools had been designed for feedback, demonstrating a gap in this matter. This work extends the prior results by analyzing empirical studies on feedback tools (in LA and EdTech community) to support SRL strategies in HE. This work aims at shedding light on designing and developing effective and actionable LA feedback tools to help students build SRL strategies, emphasizing the importance of connecting theory and analytics. This critical issue has been identified in LA and EdTech communities. Before conducting our literature review, we thoroughly reviewed and analyzed one literature review [7] and two empirical works [10], [11] in SRL that used feedback tools or LA solutions. To help define our research questions, we considered the SRL models, feedback characteristics, LA techniques, and the context these studies unfolded. Next, we present five Research Questions (RQ) and their motivation, summarized in Table I and Table II.

A. *RQ1. What models and related aspects of SRL are considered for LA feedback tools?*

One critical aspect of prior works is that very few empirical works report theoretical models to support the design and development of LA feedback tools. Yet, those few works that have informed its theoretical motivation, did this based on

different SRL models. For instance, Matcha et al. [7] supported their SRL literature review in LADs using the Winne and Hadwin model (1998) [12]. On the other hand, Lim et al. [10] reported the impact of an LA feedback tool through the lens of Zimmerman's SRL model [3]. Therefore, we are interested in identifying the *SRL theoretical models considered when developing feedback tools*. In addition, we also want to recognize if the feedback tools exploit any *phase* of the SRL model. Finally, we also want to provide insights about the different *learning strategies or aspects of SRL in the feedback tools*, as suggested in [6], [7], where both works reported that several LADs and EdTech tools were mainly designed and implemented to include specific SRL strategies such as task identification, goal setting and planning, and the enactment of study tactics [12].

B. *RQ2. What are the characteristics of the LA feedback tools?*

Timely and actionable feedback can support teaching and learning processes in a personalized manner [13]. High-quality feedback should include information about the intended goals, the current student's performance, and information that can help students develop strategies to close the gap between their recent performance and the desired goal. In turn, self-regulation implies autonomy, self-control, self-direction, and self-discipline. Hattie and Timperley [9] suggest that feedback can be a fundamental process of the SRL model, which seeks to impact the task, personal, and self-regulation levels. In this literature review, we are interested in exploring the different characteristics of the feedback that has been reported in prior works, specifically: *who leads it* (e.g., teacher, peer), *to whom it is targeted* (e.g., students, teachers, researchers), *what information is provided in the content of it* (e.g., teacher or student information), *what is the goal of it* (e.g., to improve learning performance, motivation), *at what level it operates* (e.g., task, process, self), *when it is given* (including the time frame – e.g., an entire semester), and *what format is used* (e.g., oral, written, dashboards).

C. *RQ3. How is the feedback connected to LA?*

LA can focus on a wide variety of data, such as digital traces from online learning environments and students' or teachers' physical activity measurements [7]. Once the data is gathered, it has to be processed into SRL indicators. Many approaches ranging from simple calculations over statistics to process mining or machine learning can be used. Finally, LA can also concern the particular feedback instrument used, such as LADs. The feedback can have as an end-user the students, teachers, or advisers. Teachers and advisers can, based on the feedback, improve their support towards the development of students' SRL skills by offering advice, remediation, call to action, etc. [13]. Therefore, this research question relates to which LA techniques are used regarding *data gathering and processing* and the *feedback process*.

D. RQ4. What is the context, and who is the target audience in the research methodology of the studies evaluating LA feedback tools?

To deeply explore the context in which these investigations have been applied, this research question is connected to the level of *education level* that students or teachers take or teach (e.g., continuing education, specialization course), their *domain or area of knowledge* (e.g., engineering, medicine), the *scope of the study* (e.g., over one period), and the *group size* for which the study provides feedback.

E. RQ5. How are LA feedback tools evaluated?

With this question, we aim to understand the evaluation and impact of SRL-feedback tools by analyzing the studies' *evaluation technique*, *evaluation method* (e.g., quantitative or qualitative), *the group size* reported for the evaluation, and the *impact found in the evaluation method* (e.g., student experience, well-being, performance, SRL). The *feedback impact* could for instance be evaluated on learning and achievement, either positive or negative, as suggested in [9].

III. METHODOLOGY

This Systematic Literature Review (SLR) is based on the guidelines by Kitchenham et al. [14]. We have taken three steps for this work, as depicted in Figure 1. For this systematic review, we considered articles published from the ten past years (i.e., since 2011). This was selected because we found an increasing interest on this research from 2011 onwards.

All the authors of this paper were involved in each stage of the systematic review process. After each step, all authors gathered and discussed the results and define the activities for the next step. The *first step* was keyword search to identify potential works and limitations of existing research about topics such as "*learning analytics*", "*feedback*", and "*self-regulation*". We selected six databases where most LA and EdTech papers can be found: Scopus, Web of Science, IEEE Xplore, ACM Digital Library, ProQuest, and Google Scholar. According to the keywords identified, the search string was established as follows: ("*learning analytics*" OR *dashboard* OR **feedback**) AND ("*time management*" OR **self-regulat**) AND *Year > 2011*". 1100 articles were retrieved using these search criteria. After removing duplicates, 763 papers were listed for further analysis. The *second step* was to select primary studies by establishing inclusion and exclusion criteria. We screened 763 papers' titles and abstracts. We included articles that contain four Inclusion Criteria (IC), such as "*feedback*" (IC1), "*self-regulation*" (including self-assessment, motivation, and personalization) (IC2), "*learning analytics*" (including dashboard, data mining, etc.) (IC3), and "*Higher Education*" (IC4). We excluded papers that were not written in English or Spanish (EC1) that were not published in Journals and Conferences (EC2), and that contained less than five pages (e.g., workshop papers and posters) (EC3). At the end of this process, we ended up with 62 articles.

In the *third step*, we analyzed the whole article. We selected articles that described empirical work reporting a feedback tool

and applying a self-regulation theory in the HE context. We removed papers that neither report a feedback tool nor offer a theoretical proposal, presented a preliminary short version of a published work, or did not have access to download. This work reviewed 31 articles to analyze five research questions and several topics (T), which were motivated in the previous section (see Table I and Table II).

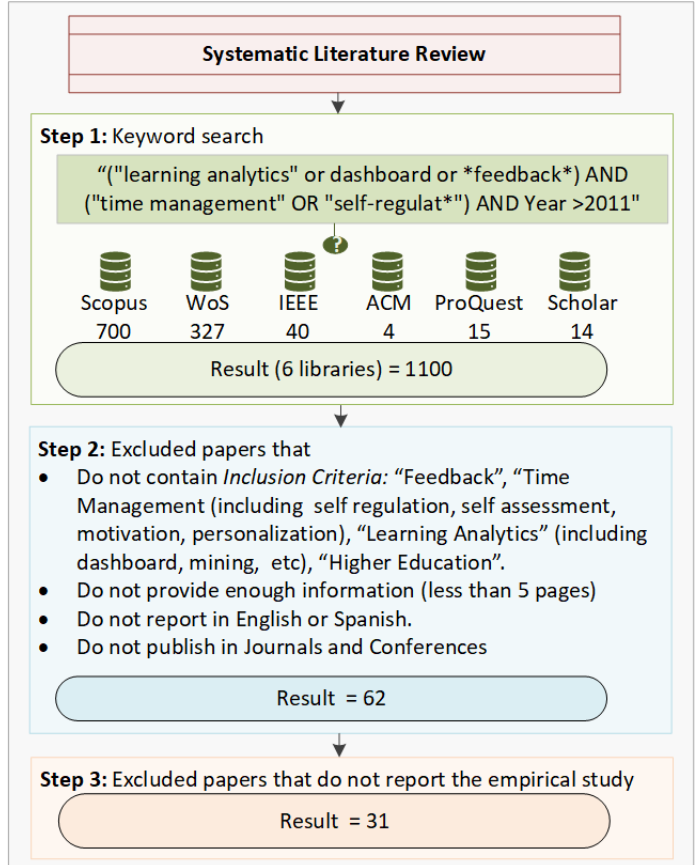


Fig. 1. Process of selecting works based on Systematic Literature Review

IV. RESULTS

This section summarizes the answers to the five research questions obtained by systematically analyzing the 31 selected papers. Table I and Table II summarizes the extracted information quantitatively.

A. RQ1. What models and related aspects of SRL are considered for feedback?

This review analyzed if the feedback supporting SRL was based on an underlying **SLR theory or model**. Despite its importance in LA, only a small number of papers (9 out of 31) mentioned to any extent the SLR theory used for delivering and evaluating feedback. Table I and Table II summarizes the different theories found in these works, such as the theory of Zimmerman (2002) [10], [15], [16], [18], Pintrich (2000) [10], [19], [20], Liaw, S. S., & Huang, H. M. (2013) [21], and the COPES model [22]. Although the minority of the

TABLE I
RESEARCH QUESTIONS, TOPICS, AND SUMMARY OF THE RESULT
(RQ1-RQ3; N=31)

Research questions and topics	Emergед answers	Studies	Results	
			#Studies	%
RQ1. What models and related aspects of SRL are considered for feedback?				
T1: SRL theoretical models	copies model	[22]	1	3%
	SRL theory from Zimmerman	[10], [15], [16], [18]	4	13%
	SRL theory from Pintrich	[10], [19], [20]	3	10%
	SRL theory from Liaw & Huang	[21]	1	3%
T2: Phases of the SRL model	task identification	[22]–[24]	3	10%
	goal setting and planning	[18], [19], [22]	3	10%
	enactment of learning strategies & study tactics, adaptation	[22]	1	3%
	forethought phase	[11], [17], [22], [30]	4	13%
	performance phase	[1], [13], [17], [18], [20], [22], [26]	7	23%
	self-reflection phase	[11], [13], [17], [22], [27]–[29]	7	23%
T3: Learning strategies or aspects of SRL	time management	[11], [17], [22], [29], [31], [32]	6	19%
	goal setting.	[11], [20], [23], [25]	4	13%
	self-questioning	[20], [26], [34]	3	10%
	performance strategies	[11], [19], [20], [22], [24], [27], [28], [31], [34]	9	29%
	attention control strategies	[11], [34]	2	6%
	evaluation strategies	[11], [20], [25], [33], [34]	5	16%
	adaptation	[11], [25], [33], [34]	4	13%
RQ2. What are the characteristics of the feedback?				
T4: Who delivers it	teacher	[10], [11], [13], [15], [17], [22], [24], [25], [28], [33]–[39]	16	52%
	computer-supported	[10], [13], [18]–[21], [23], [26], [27], [31], [32], [40]	12	39%
T5: To whom it is targeted	students	[10], [11], [15], [17]–[26], [28], [30]–[40]	25	81%
	teachers	[13]	1	3%
	instructors	[29]	1	3%
T6: what information is provided in the content	student/teacher information	[10], [11], [13], [15], [17]–[20], [22]–[25], [30], [32]–[39]	21	68%
	peer information	[22], [29], [32], [41]	4	13%
T7: Goal	student performance improvement	[19], [23], [34], [40]	4	13%
	at-risk students support	[15], [26]	2	6%
	students' learning processes supervision	[13]	1	3%
	self-regulation skills support	[18], [20], [22], [24], [34]	5	16%
	student's behavior impact	[30], [32], [37], [38]	4	13%
	students' experience evaluation	[10], [34]	2	6%
	mentoring skills support	[25]	1	3%
T8: Level at which the feedback operates	task level	[10], [15], [19], [20], [23], [24], [29], [33]	8	26%
	process level	[18], [20]–[22], [24], [26], [32], [33]	8	26%
	self-regulation level	[11], [17], [18], [20], [22], [25]–[27], [30], [34], [36]–[38]	13	42%
T9: When is it given	self-level	[26], [28], [39]	3	10%
	post-hoc	[10], [11], [18], [19], [21]–[23], [25], [26], [32], [33], [35], [37]–[39], [41]	16	52%
	during advisor-advisee meetings	[15]	1	3%
	at the end of each week	[13]	1	3%
	during a computer-based learning session	[20]	1	3%
T10: Time frame	entire time span of feedback process	[11], [13], [15], [18], [20]–[23], [26], [28], [32]–[34], [36]–[39], [41]	18	58%
	during the course	[13], [23], [34]	3	10%
	whole semester	[5], [10], [18], [21], [25], [28]	6	19%
T11: Format	oral	[11], [15], [20], [28], [31], [34]	6	19%
	written	[10], [11], [13], [17]–[20], [22], [25]–[27], [31]–[35], [37]–[40]	20	65%
	others.	[15], [21], [23], [24], [30], [36], [41]	7	23%
RQ3. How is the feedback connected to LA?				
T12: Data gathering	LMS and quizzes	[10], [11], [13], [15], [17]–[23], [30], [32], [34], [35], [37], [38]	17	55%
T13: Data processing	log data into SRL indicators	[13], [18], [22], [23], [32]	5	16%
	dashboard	[15], [18], [22], [23], [26], [32], [36], [41]	8	26%
T14: LA technique applied	data mining	[13], [17], [23], [24], [27], [34], [37]	7	23%
	others	[10], [11], [19], [21], [28]–[30], [33], [35], [36], [38], [39]	12	39%

TABLE II
RESEARCH QUESTIONS, TOPICS, AND SUMMARY OF THE RESULT
(RQ4-RQ5; N=31)

Research questions and topics	Emerg ed answers	Studies	Results	
			#Studies	%
RQ4. What is the context, and who is the target audience in the studies?				
T15: Education level that students/teachers take/teach	higher education	[10], [11], [13], [15]–[41], [43]	31	100%
	specialization course	[23], [27], [29]	3	10%
T16: Domain or area of knowledge that students/teachers are related to	engineering	[10], [18], [21], [29], [32], [33], [38]	7	23%
	language programs	[11], [35], [37]–[39]	5	16%
	psychology	[20]	1	3%
	others	[13], [17], [19], [22], [24]–[26], [28], [30], [31], [34], [41]	12	39%
T17: Scope of the study carried out	period during which feedback was provided	[11], [15], [20], [21], [23], [28], [33]	7	23%
	students/teachers who received feedback belong to a specific course	[10], [15], [18], [22]–[24], [26], [32], [39]	9	29%
	to several courses of a career to a course module	[27], [29], [30], [34], [35], [37], [38], [41] [22]	8 1	26% 3%
T18: Group size for which the study provides feedback	40 to 1000 and more	[10], [11], [13], [15], [16], [18]–[20], [22]–[24], [26], [31]–[37], [41]	20	65%
RQ5. How is the feedback evaluated?				
T19: Study evaluation technique	questionnaires (self-report)	[11], [18], [19], [21], [22]	5	16%
	interviews	[11], [13]	2	6%
	surveys	[13]	1	3%
	log traces when using the platform (teachers)	[15]	1	3%
T20: Evaluation method	quantitative	[10], [11], [13], [15], [17]–[21], [23], [24], [26], [27], [31]–[33], [35], [37]	18	58%
	qualitative	[10], [11], [13], [19], [22], [23], [28], [33], [35], [37]	10	32%
T21: Group size considered in evaluation	studies varied from 5 to more than 1000	[11], [13], [15]–[18], [20]–[24], [26], [29]–[31], [34], [36]–[39]	20	65%
	well-being	[30]	1	3%
	performance	[13], [17], [20], [23], [26], [28], [29], [33], [35], [41]	10	32%
	SRL	[11], [13], [15], [28], [32]–[34], [36]–[38]	10	32%

papers explicitly identified an SRL theory, we analyzed if the feedback provided to stakeholders targeted a particular **SRL phase**. To this end, we used both the COPEs model [7] and Zimmerman’s model [3]. Regarding the COPEs model, we found studies reporting SRL phases such as *task identification* [22]–[24], *establishing goals and planning* [18], [19], [22], *study skills* [22], [25], and *adaptation* [22]. Among these, the work of Konert and colleagues [22] examined three phases of the COPEs model. Regarding Zimmerman’s model [3], the most examined phases are the *performance* [1], [13], [17], [18], [20], [22], [26] and *self-reflection* [11], [13], [17], [22], [27]–[29] phases. The forethought phase was presented to a lesser extent [11], [17], [22], [30]. Regarding the topic about **learning strategies or aspects of SRL considered for feedback**, the top three learning strategies that we recognized were *performance* strategies (29%) [11], [19], [20], [22], [24], [27], [28], [31], [34] followed by *time management* (19%) [11], [17], [22], [29], [31], [32] and *evaluation* (16%) [11], [20], [25], [33], [34] strategies.

B. RQ2. What are the characteristics of the feedback?

This review examined different feedback characteristics. Regarding the question of **who delivered the feedback**, in most

of the studies (52%), the *teacher* had the role of delivering the feedback [10], [11], [13], [15], [17], [22], [24], [25], [28], [33]–[39]. We also found that there are several works (39%) showcasing *computer-supported* feedback [10], [13], [18]–[21], [23], [26], [27], [31], [32], [40], for example, through Learning Management Systems (LMS) [10], [26]. Most of the papers (81%) indicate that students **receive the feedback** [10], [11], [15], [17]–[26], [28], [30]–[40]. The minority of works covered *pre-service teachers* [13] or *instructors* [29] as feedback consumers. The rest of the papers, corresponding to a 4%, did not specify this criterion. Another feedback characteristic is the **information provided in the content**. As expected, most of the feedback contains *student or teacher information* (68%) [10], [11], [13], [15], [17]–[20], [22]–[25], [30], [32]–[39]. For example, Lim et al. [10] provided check-point analytics as feedback gathered from student information. To a lesser extent, the feedback is presented as a combination of student or teacher information compared with *peer information* [22], [29], [32], [41] such as in the work of Konert et al. [22], where they leveraged peer feedback through an LMS by providing individual and peer information to support social comparison of time investment strategies in a MOOC.

In relation to the **feedback goal**, the majority of studies (77%) clearly stated its main goal [11], [13], [15], [18]–[26], [28], [30]–[40]. We identified seven goals as the most chosen: *student performance improvement* [19], [23], [34], [40], *at-risk students support* [15], [26], *students' learning processes supervision* [13], *self-regulation skills support* [18], [20], [22], [24], [34], *student's behavior impact* [30], [32], [37], [38], *students' experience evaluation* [10], [34], and *mentoring skills support* [25]. Regarding the **level** where the feedback operates, 42% of the papers related to feedback at the *self-regulation level* as defined by Hattie and Timperley [11], [17], [18], [20], [22], [25]–[27], [30], [34], [36]–[38], whereas 10% operates at the *self-level* [26], [28], [39]. Almost all articles indicated that the feedback was presented *post-hoc* (after the enactment of the learning activity), and in different cases, for example, during advisor-advisee meetings [15], or at the end of each week [13]. Only the work presented in [20] described that the feedback was provided during a computer-based learning session. In addition, we identified the **time frame when the feedback was provided** in 58% of the works [11], [13], [15], [18], [20]–[23], [26], [28], [32]–[34], [36]–[39], [41]. The results indicate that feedback on SRL usually spans a more prolonged period, for example, during the course (12 weeks) [13], [23], [34], during a summer course (7 weeks), or throughout the whole semester [5], [10], [18], [21], [25], [28]. Note that a 12-week module or a whole semester module may correspond to a course due to the several locations where these studies were applied. Also, the results suggest diverse feedback interventions, pointing to a single intervention (e.g., one lesson of 100 minutes [20] or a mid-term checkpoint [26]) or several interventions (e.g., at the end of each week [13], overviewing a longer academic period [39]). Finally, concerning the **format of the feedback**, the results indicate that most of the feedback is given in a *written* manner (65%) [10], [11], [13], [17]–[20], [22], [25]–[27], [31]–[35], [37]–[40], followed by *oral* feedback (19%) [11], [15], [20], [28], [31], [34]. Surprisingly, 23% of the papers did not mention explicitly how the feedback was provided [15], [21], [23], [24], [30], [36], [41]. It is worth noting that, during our analysis, we considered written feedback as any type of information is given through a system (e.g., LMS [e.g., [13]], a dashboard [e.g., [15], [20], [22], [23], [32]], or a web page [19], among others).

C. RQ3. How is the feedback connected to LA?

LA techniques can support data gathering, data processing, and the actual delivery of feedback. 17 papers were found to use LA techniques regarding data gathering in order to measure SRL [10], [11], [13], [15], [17]–[23], [30], [32], [34], [35], [37], [38]. Most prominent were the data coming from online student activity in the LMS (e.g., days and number of logins to the LMS, the number of views on weekly course videos and e-books, the frequency of participation in the forum environment [13]), and assessment data (assessment scores on weekly assignments or quizzes or knowledge levels obtained from such assessments [18]). Additionally, another source of data was self-reported data through the LMS (e.g.,

self-set goals, surveys to measure students' perceptions or overall experience or beliefs) [11], [13], [15]. Five papers were found where LA was reported to be used to process data into **indicators of SRL** for feedback [13], [18], [22], [23], [32], while seven stated explicitly that data mining techniques were used [13], [17], [23], [24], [27], [34], [37]. This can include prediction [11], personalized recommendations or messages [13] or methods to calculate the total time spent or type of learning behavior [32]. According to **LA techniques** used to deliver the feedback, *dashboards* were most prevalent (8, [15], [18], [22], [23], [26], [32], [36], [41]).

D. RQ4. What is the context, and who is the target audience in the studies?

From the pool of 31 papers, three were identified as specialization courses [23], [27], [29] (e.g., workshops or optional courses). Different study domains were presented, with *engineering* (23%) [10], [18], [21], [29], [32], [33], [38] being the most prevalent one; the remaining did not specify any domain or area of knowledge. Among other areas, we found that the studies are often conducted in the context of *STEM* (science, technology, engineering, and mathematics) [13], [17], [26], [34], [36], [41], *Psychology* [20], or *Language programs* [11], [35], [37]–[39]. In terms of the scope of the study, 29% of the papers reported that the feedback was given to a specific course or a course module [10], [15], [18], [22]–[24], [26], [32], [39], while 26% of papers relate to several courses [27], [29], [30], [34], [35], [37], [38], [41]. To a lesser extent, studies are reporting the provision of feedback to different universities [17] or several cohorts [19]. Also, one study reported three different scopes for validating the study: an academic year, a two-week workshop, and a course module [23]. Regarding the *group size*, feedback is targeted to group sizes between 40 to 1000 and more [10], [11], [13], [15], [16], [18]–[20], [22]–[24], [26], [31]–[37], [41].

E. RQ5. How is the feedback evaluated?

This research question helps understand the evaluation and impact of the feedback that empirical studies have followed methodologically. There were several evaluation techniques derived from the papers in this review, such as questionnaires (*self-report*) [11], [18], [19], [21], [22], *interviews* [11], [13], *surveys* [13], *log traces when using the platform* (teachers) [15], among others. Considering the evaluation method, *quantitative* methods are commonly used as expected (58%) [10], [11], [13], [15], [17]–[21], [23], [24], [26], [27], [31]–[33], [35], [37] due to the easiness of collecting data through a computer-based system. 32% of studies reported *qualitative* methods [10], [11], [13], [19], [22], [23], [28], [33], [35], [37]. These were carried out through questionnaires [13], [18], [19], [21], [23], surveys [18] and interviews [11], [13], [23], [37], among others. Also, the evaluation and impact of a feedback tool are given by its generalization of results, which is linked to the group size of the study. Our results indicated that the number of participants involved in the studies varied from 5 to more than 1000 [11], [13], [15]–[18], [20]–[24],

[26], [29]–[31], [34], [36]–[39]. Finally, regarding the impact of the feedback intervention, studies often have investigated the impact on students’ performance (32%) [13], [17], [20], [23], [26], [28], [29], [33], [35], [41] and as proxies of SRL strategies (32%) [11], [13], [15], [28], [32]–[34], [36]–[38]. To a lesser extent, studies have examined the impact on students’ well-being [30].

V. DISCUSSION AND CONCLUSION

This work presents a systematic literature review on how LA is used empirically to support the provision of feedback to support self-regulation in higher education. Our results reveal that the research, at least in the consulted databases, is relatively limited (31 papers in the last ten years).

Similarly, to the review of Matcha et al. [7], which reviewed empirical studies on Learning Analytics Dashboards (LADs) from an SRL learning perspective, and in line with the thought of Viberg et al. [8] which focused on empirical research of SRL and LA in online environments, we found that most of the papers often lack a solid theoretical basis (RQ1). While we explicitly searched for articles that report empirical work to support SRL, only 9 out of 31 clearly showed how their work was grounded in existing accepted SRL theoretical frameworks. The feedback is most often delivered directly to students, by teachers, or automatically by a computer-based system that provides automatic feedback as it would come from a teacher or advising agent (RQ2). Therefore, there is still a research gap regarding feedback to other intermediary stakeholders in the learning process, such as teachers, advisors, or peer students. It is also imperative to use this feedback timely, following the best strategies to support students and without being a burden for the teacher. Therefore, Higher Education institutions are in the urge need to investigate and develop best practices to support students’ SRL. Literature indicates that LA support data gathering, data processing, and the actual delivery of feedback SRL feedback where the latter is most often done by LA dashboards (RQ3). Most of the research have used log data from LMS, which is usually limited as these data do not reflect the whole SRL process of students. This suggests that there is still a gap on how to map between educational log data coming from other sources (e.g., physiological data from sensors and video, [42]) and SRL constructs to provide feedback. Empirical research covering multiple educational domains, different universities, and multiple cohorts is still limited (RQ4). The evaluation of the empirical research is often somewhat limited, lacking a solid methodology where the majority uses a quantitative approach, evaluating a limited set of case studies (or most even single) in a particular context and with small sample size (RQ4, RQ5). Moreover, most papers limit themselves to a causal relationship between introducing the feedback and an outcome measure. Furthermore, the outcome measured differs significantly from usability (which one could even argue is not an outcome measure but just part of the design phase of the dashboard), perceived usefulness, perceived level of support, higher activity level, improved SRL skills, and

increased academic performance, or teaching proficiency. As Viberg et al. [8] also indicated, only a few papers show a causal impact between the dashboard and their outcome measure. Our systematic literature review, therefore, calls to action to perform empirical research on LA supported feedback to support SRL that uses robust methodologies, combines a quantitative and qualitative approach, is applied in diverse contexts, goes beyond usability and perceived usefulness assessments, and aims at clarifying if any causal relationship can be found between the provision of the SRL-feedback and stakeholders’ well-being or professional level of support, SRL skills, learning or teaching activities, and even academic performance or persistence.

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