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Lifelong learner needs for human-centered self-regulated learning analytics

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Abstract

Purpose – Self-regulated learning (SRL) is crucial for successful learning and lifelong learning in today's rapidly changing world, yet research has shown that many learners need support for SRL. Recently, learning analytics has offered exciting opportunities for better understanding and supporting SRL. However, substantial endeavors are still needed not only to detect learners' SRL processes but also to incorporate human values, individual needs and goals into the design and development of self-regulated learning analytics (SRLA). This paper aims to examine the challenges that lifelong learners faced in SRL, their needs and desirable features for SRLA.

Design/methodology/approach – This study triangulated data collected from three groups of educational stakeholders: focus group discussions with lifelong learners ($n = 27$); five teacher interviews and four expert evaluations. The groups of two or three learners discussed perceived challenges, support needs and willing-to-share data contextualized in each phase of SRL.

Findings – Lifelong learners in professional development programs face challenges in managing their learning time and motivation, and support for time management and motivation can improve their SRL. This paper proposed and evaluated a set of design principles for SRLA.

Originality/value – This paper presents a novel approach for theory-driven participatory design with multistakeholders that involves integrating learners, teachers and experts' perspectives for designing SRLA. The results of the study will answer the questions of how learners' voices can be integrated into the design process of SRLA and offer a set the design principles for the future development of SRLA.

Keywords Participatory design, Professional development, Learning analytics, Self-regulated learning, Lifelong learning, Design principles

Paper type Research paper

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1. Introduction

Self-regulated learning (SRL) refers to the cyclical process in which learners actively and reflectively plan and adapt their learning to achieve their goals (Järvelä *et al.*, 2018; Zimmerman, 2000). Being able to regulate one's own learning is a critical aspect of successful learning and can enhance academic performance and motivation (Theobald, 2021). Furthermore, SRL is essential for lifelong learning because learners need to be able to monitor and control their learning throughout their lives in today's rapidly changing world (Taranto and Buchanan, 2020). Despite the importance of SRL, many learners struggle with SRL, particularly in the face of complex and demanding learning tasks (Koivuniemi *et al.*, 2017). This can lead to frustration, disengagement and poor performance (Anthonysamy *et al.*, 2020). Some students may need support to regulate their own learning effectively, and achieving self-regulation can be difficult for them.

However, due to the complexity of SRL processes, its measurement has been a major challenge (Järvelä and Bannert, 2021). To address this challenge, researchers have started to use various data streams and learning analytics (LA) to unobtrusively measure facets of the SRL to provide personalized support for the different phases of SRL, even in real-time (Azevedo and Gašević, 2019). At its best, personalized support promotes learners' SRL and, as a result, helps them to become more successful learners (Lim *et al.*, 2023). Although the advancement of LA has offered several insights and tools to better understand and promote SRL (Järvelä *et al.*, 2023), a significant amount of effort remains to be put into designing LA systems that support learning with the consideration of individual goals, authentic educational needs and ethical principles (Sarmiento and Wise, 2022).

Human-centered LA has gained prominence as a distinct approach to the design and implementation of LA systems that prioritize the needs and perspectives of learners and teachers. Recent calls have asked for learners' voices to be considered, along with the involvement of teachers in LA design, to increase LA's transparency, acceptability and successful implementation across contexts (Buckingham Shum *et al.*, 2019). Building on this foundation, participatory design methodologies have been recognized as an effective means for achieving human-centered LA (Bødker *et al.*, 2022). These methodologies actively involve end-users, namely, learners, in the design process, thereby ensuring that the analytics solutions are tailored to their requirements and contextual realities. Nevertheless, as the majority of current human-centered LA studies focus on higher education, it is essential that human-centered LA studies also address other learning contexts, such as lifelong learning and workplace learning.

In this paper, we respond to these recent calls by examining lifelong learner voice for self-regulated learning analytics (SRLA) in lifelong learning. Moreover, the findings from lifelong learner voice are corroborated with their teacher's voice for validation. In designing LA, it is important to define the stakeholders who can and should participate (Dollinger *et al.*, 2019). Thus, balancing learner voice and teacher voice can be considered because each perspective offers unique insights. On the one hand, learner voice needs to be considered in the design of LA because students are the ultimate users of the system, and their perspectives on how it can benefit their SRL process are essential. On the other hand, teachers have a wealth of knowledge about teaching and learning and their perspectives can help ensure that the system is designed to meet the needs of both students and teachers. This paper examines learners' challenges and desirable LA features in each SRL phase from both lifelong learners' and teachers' perspectives.

Nevertheless, when it comes to human–computer interaction, it is well-known that users do not always know or are certain about what they want, especially with advanced novel technologies that have the potential to change the way people work

(Buckingham Shum *et al.*, 2019; Dollinger *et al.*, 2019; Martinez-Maldonado *et al.*, 2021). This concern also applies to human-centered LA, that learners and teachers may not be fully aware of the effectiveness and undesirable consequences of the LA features. As a result, we argue that triangulating learner and teacher voices with domain expert opinions will ensure that the system meets their needs and provides a positive experience. Furthermore, by considering the pertinent learning theories, human-centered LA can be designed based on a solid understanding of the process of learning and is more likely to be effective in supporting learner success.

In this paper, we seek to address the recent calls by examining learners' needs and aligning those with SRL theory and LA design principles to formulate design principles for SRLA. To address this aim, first, we propose a methodology that considers SRL theory and integrates both learners, teachers and LA experts' perspectives for designing SRLA. Second, we apply the proposed methodology in a professional development context and illustrate how the methodology can be used to develop a set of design principles for SRLA. In particular, we seek to answer the following research questions (*RQs*):

RQ1. How can learners' and teachers' voices be integrated with learning and design theories into the design process of SRLA?

RQ2. What are the design principles for SRLA?

In the following section, we first establish the theoretical foundations for the study by reviewing the literature on SRL in lifelong learning for professional development and SRLA. Then, we introduce our theory-driven participatory design with multistakeholders (TPDM) method for integrating learner needs in establishing design principles for SRLA. We present and evaluate the voice of lifelong learners on their SRL challenges and desirable SRLA features. The design principles for SRLA were established as prescriptive statements that guide the future development of SRLA. After presenting and evaluating the set of design principles for SRLA, we discuss the implications of our study and we conclude by discussing its limitations and future research directions.

2. Theoretical foundations

2.1 Self-regulated learning in lifelong learning for professional development

SRL constitutes a dynamic framework that describes the processes by which learners personally orchestrate their cognitive, metacognitive and motivational strategies to attain their educational goals (Zimmerman, 2000, 2002; Järvelä *et al.*, 2018). Learners who exhibit proficiency in SRL engage in a systematic sequence of planning, implementation and adaptation, which encompasses the setting of specific learning objectives, the continuous monitoring of their progress and the recalibration of their strategies when circumstances necessitate such changes. The significance of SRL transcends the immediate context of academic settings, holding implications for students' long-term academic success, motivation and engagement (Theobald, 2021). SRL serves as a critical scaffold that not only augments students' academic performance but also fuels their intrinsic motivation to learn, thereby offering a synergistic effect on their educational outcomes.

SRL extends its importance to the domain of lifelong learning, especially within the scope of professional development. Lifelong learning is an ongoing process extending beyond formal educational structures, often taking the form of informal or nonformal education embedded in daily activities and occupations (Milligan and Littlejohn, 2014). Within the framework of this study, professional development is defined as a type of lifelong learning aimed at enhancing career-specific skills. Contemporary society, characterized by an

accelerated pace of technological advancements, mandates an ongoing learning process for individuals to remain adaptable and competent (Taranto and Buchanan, 2020).

In this regard, SRL emerges as an indispensable skill set for continuous growth and adaptability, empowering individuals to meet the challenges and opportunities presented by a digitized and dynamic global landscape. This can occur in various learning settings such as informal workplaces, nonformal educational platforms, as well as online and offline courses. Previous studies confirm the significance of SRL in empowering learners to actively acquire the requisite skills and competencies in a fast-paced, technology-driven society (Taranto and Buchanan, 2020). These findings align with well-established SRL strategies such as self-assessment, goal setting and self-reflection (Zimmerman, 2000). Accordingly, this study focuses on a nonformal online academy designed to teach digital skills over a period of three to six months to adult learners with diverse educational and professional backgrounds.

Research evidence suggests that the capability for SRL is especially pertinent for lifelong learners in professional development settings (Persico *et al.*, 2015, 2020). Milligan and Littlejohn (2014) identify four key behaviors that are integral to SRL in these contexts as: consume, create, connect and contribute. Furthermore, the educational environment in professional development is often less structured, requiring a higher degree of self-regulation from learners (Milligan and Littlejohn, 2014). In such educational landscapes, students exercise greater agency over their learning paths, choosing subjects and pacing autonomously (Manganello *et al.*, 2021). The design of digital skills boot camps, such as the one examined in this study, often incorporates pedagogical techniques that necessitate active participation from the learner (Moshirpour *et al.*, 2019).

However, it should be acknowledged that not all individuals readily use SRL strategies in their learning processes. Challenges in practicing SRL can manifest in the form of poor task management or emotional regulation, ultimately leading to reduced academic performance or disengagement (Koivuniemi *et al.*, 2017; Anthonysamy *et al.*, 2020). Given these challenges, it is imperative that educational settings provide adequate support to facilitate learners' SRL strategies.

In this study, Zimmerman and Moylan (2009) SRL model is adopted as the theoretical framework for investigating learners' challenges in the different phases of SRL and the needs for SRLA. The model depicts the SRL process in three phases of SRL in which the output of the previous phase provides input to the next phase: (i) forethought including task analysis and self-motivation beliefs, (ii) performance including monitoring and controlling one's learning and (iii) self-reflection including of self-judgment and self-reaction. In the context of professional development, learning is mostly informal and learners are required to take decisions not only about how and when to learn but also about what to learn (Manganello *et al.*, 2021).

2.2 Self-regulated learning analytics

The advancement of the LA field has offered unique capabilities for better understanding and supporting SRL. LA refers to "the application of data analytic techniques and tools for the purposes of understanding and enhancing learning and teaching" (Nguyen *et al.*, 2020). The literature has shown that LA delivers remarkable benefits to the learners, such as providing insight in a timely manner to improve outcomes (Knight and Buckingham Shum, 2017), identifying learning needs and providing personalized learning support (Nunn *et al.*, 2016). For instance, Arnold and Pistilli (2012) demonstrated how real-time analytics could be used to identify at-risk students in the early stages of a course by integrating data from various sources, such as grades, course interactions and past academic performance, to

generate "traffic light" indicators. Nevertheless, prior studies have called for better alignment between LA design and learning theories to maximize its impact on learning (Gašević *et al.*, 2015). In particular, Heikkinen *et al.* (2022) noted in their systematic literature review that achieving the full potential of SRLA requires that the different phases of SRL are considered when designing and developing LA solutions.

When learners enact in forethought, performance or self-reflection phases, there are several affordances of LA that can promote SRL (Persico *et al.*, 2015). First, SRLA can help learners to monitor their own learning and to make data-informed decisions on controlling their learning accordingly (Manganello *et al.*, 2021). Second, SRLA can provide personalized scaffolds and guide learners to use specific learning materials or resources that promote SRL (Lim *et al.*, 2023). Third, SRLA could be used to promote self-reflection by engaging learners in self-assessment of their own learning (see Domínguez *et al.*, 2021). While alignment between LA design and learning theories is necessary, it alone is not sufficient to guarantee the design of good LA tools. Therefore, when designing such tools, it is critical to also consider the needs of nontechnical stakeholders, including students and teachers (Giacomin, 2014).

Furthermore, recent research has made significant contributions to the field of LA by offering various strategies that give students and teachers a voice (Alvarez *et al.*, 2020; Buckingham Shum, 2022; Prieto-Alvarez *et al.*, 2018). This has led to the development of human-centered LA in which critical stakeholders (students, teachers), learning and teaching environments and their relationships are identified and considered (Buckingham Shum *et al.*, 2019). Human-centered LA is often achieved through participatory design that offers an innovative approach for ensuring that analytics tools are both effective and closely aligned with the specific needs of learners (Sarmiento and Wise, 2022). First, designing the LA tools with learners and teachers can inform them on the what, how and why the different kinds of data are collected, including how LA tools will acquire and interpret the data to promote SRL (Mangaroska *et al.*, 2021). This increased transparency and acceptability of these tools can also foster their long-term use. Second, by using human-centered LA, both students and teachers may be better equipped to derive meaningful insights and make informed decisions based on SRLA. Namely, learners' and teachers' implementations of LA tools may differ from the purposes of designers (Wang and Hannafin, 2005), so designing the interventions with students and teachers may bridge the gap between the desired SRL processes and strategies and those actually realized (Schumacher and Ifenthaler, 2018).

Within the context of SRLA, central to SRL is the notion of learner agency, autonomy and self-reflection, elements that are naturally supported by participatory design methodologies (Zimmerman, 2000). Inviting learners to be active participants in the design of analytics systems ensures that the resultant tools better reflect learner requirements, preferences and contexts (Shum and Ferguson, 2012). Consequently, this participative and multidimensional approach not only yields SRLA tools that are more contextually apt but also reinforces the foundational principles of SRL by encouraging learner input and agency.

Even though the lack of students involvement in the design processes has been acknowledged (Buckingham Shum *et al.*, 2019; Mangaroska *et al.*, 2021), considering only their voice in designing SRLA is questionable because students understanding of effective SRL processes and strategies may be limited (Bjork *et al.*, 2013). Even though the different stakeholders (students and teachers) can have different or even conflicting voices during design processes (Bødker *et al.*, 2022), it is important to investigate both voices to validate design principles for SRLA. Accordingly, this design study seeks to formulate design principles for SRLA by synthesizing the voices of both students and teachers with solid

theoretical foundations (Zimmerman and Moylan, 2009) and subsequently subjecting these principles to experts in SRL and LA.

3. Research methodology

To formulate a set of design principles for human-centered SRLA, this study used the well-known design science research methodology in information sciences research (Peffers *et al.*, 2007) in conjunction with a participatory design approach (Bødker *et al.*, 2022). This approach prioritizes the values and concerns of learners as end-users in the design of LA. However, it is important to note that the needs and preferences of learners may conflict with the instructional values held by teachers; such tensions must be addressed. Additionally, in extreme scenarios, the needs and preferences of learners could potentially have adverse effects on their learning outcomes. As such, integrating the perspectives of teachers is imperative for a balanced approach, and the application of learning theories is crucial for guiding the design of human-centered SRLA. Thus, drawing upon the design science research methodology and the participatory design approach, we present our TDPM approach as a methodological framework for formulating design principles for SRLA.

3.1 Design science research methodology

The design science research methodology by Peffers *et al.* (2007) serves as a comprehensive set of guidelines encompassing principles, practices and protocols for carrying out studies that focus on the design and development of artifacts for information systems, particularly educational technology (e.g. Nguyen *et al.*, 2021). Its core aim is to develop pragmatic solutions to identified issues by emphasizing a multistage process that entails artifact creation, scientific contribution, design evaluation and result dissemination. The resultant artifacts can manifest in various forms, ranging from constructs and models to methods and instantiations, as well as design principles (Baskerville *et al.*, 2018; De Leoz and Petter, 2018).

In the context of the present study, the research output took the form of design principles aimed at human-centered SRLA. The execution of the study followed the structured steps delineated by the design science research methodology:

- identifying and substantiating the problem;
- formulating solution objectives;
- engaging in design and development;
- demonstrating the artifact;
- evaluating the artifact; and
- disseminating findings (Peffers *et al.*, 2007).

In this study, the initial step involved identifying the research problem, which centered on the necessity of supporting SRL for lifelong learners via human-centered SRLA. The study's objectives, encapsulated in its aim and research questions, focused on investigating the specific needs of learners and crafting design principles tailored for human-centered SRLA. Following this, the stages of design, development, demonstration and evaluation were carried out using a participatory design method (Bødker *et al.*, 2022), adapted into the proposed TPDM approach to fit the study's objectives. Finally, the study's results and findings served as the vehicle for communication in line with the design science research methodology.

3.2 Theory-driven participatory design with multistakeholders

In this study, we present an approach for TPDM. Figure 1 illustrates our TPDM approach for integrating learner needs in establishing design principles for SRLA.

Based on SRL theory, learners' focus group discussions and teacher interviews are triangulated to determine learner needs. Together with design principles for generic learning analytics information systems (LAIS), the findings are incorporated into the conceptualization of SRLA design principles. Both the learner needs and conceptualized design principles are iteratively evaluated by experts based on the following three evaluation criteria (adopted from Venable *et al.*, 2012): 1) evaluate the artefact to establish its utility and efficacy for achieving its stated purpose; 2) evaluate the artefact to identify weaknesses and areas of improvement; and 3) evaluate the artefact to identify side effects or undesirable consequences of its use.

4. Design requirements and inputs – lifelong learners' self-regulated learning challenges and desirable learning analytics features

In this section, we focus on the essential design requirements and inputs that will inform the foundational principles of SRLA. These guiding elements are derived from the thematic analysis of Learner Focus Group Discussions and Teacher Interviews. By examining these rich narratives, we identify the specific challenges that lifelong learners face in their learning journeys. We also discern the LA features that both learners and teachers consider most desirable for enhancing lifelong learners' SRL. This multistakeholder insight serves as the cornerstone for establishing empirically grounded and contextually relevant design principles for SRLA.

4.1 Participants and procedures – learner focus group discussion and teacher interviews

The study started with data collection from two groups of participants which are the learners and the teachers. The first group of participants was learners who joined three- to

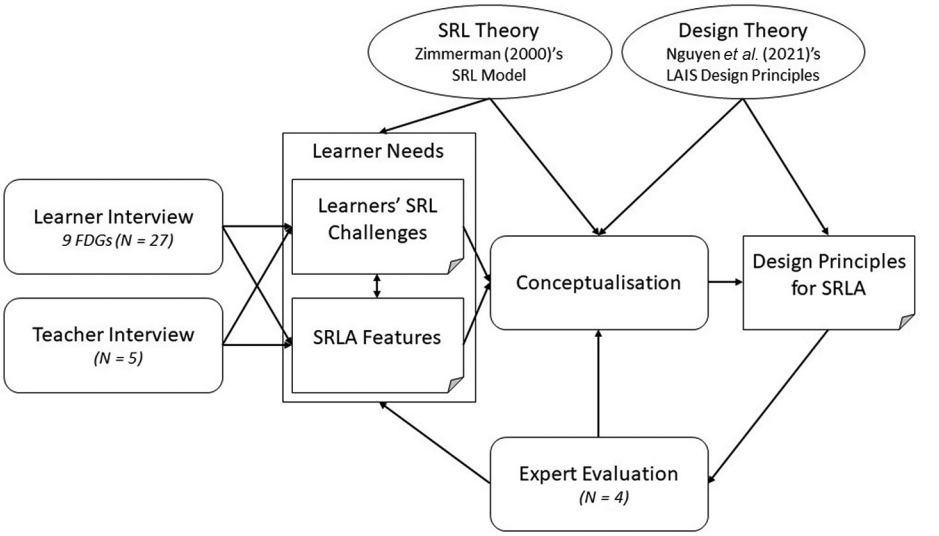

Figure 1.
Theory-driven participatory design with multistakeholders (TPDM) for integrating learner needs in establishing design principles for self-regulated learning analytics (SRLA)

Source: By authors

six-months digital skills courses (e.g. Full-Stack Web Development, User Interface and User Experience, Data Science, Digital Marketing) in a nonformal online professional development academy, also known as an online boot camp. Qualitative data collection through focus group discussion was applied to acquire the learners' voices on the challenges in applying SRL during their learning process and the desirable SRLA features to support them. In total, there were 27 students ($n = 27$) who formed into ten focus groups consisting of two (three groups) to three learners (seven groups) in each group. All study participants are Indonesian; their demographic characteristics are summarized in Table 1. The topics and guiding questions for the focus group discussion are depicted in Appendix 1.

The second group of participants was the teachers ($n = 5$) who facilitated the courses and assisted the learners during their learning process in the mentioned online boot camp. The semistructured interview was conducted to gather the teachers' voices on the observable learners' challenges and the desirable SRLA features to support the learners in practicing SRL. Similar questions (Appendix 1) were asked to obtain teachers' perspectives on learners' challenges in SRL and features that may help the learners improve their SRL.

4.2 Thematic analysis

The data collected from the learners' focus group discussions and teachers' semistructured interviews were analyzed using a thematic analysis approach. Thematic analysis is a widely used qualitative method for identifying, analyzing and reporting patterns or themes within the data (Braun and Clarke, 2006). The aim of the thematic analysis in this study was to examine the voices of the learners and validate them with a balance with teacher voice. The integrated voices from both learners and teachers were then conceptualized with iterative expert evaluation for establishing design principles SRLA.

The process of data analysis included several stages, and the NVivo-12 software, a commonly used tool for qualitative analysis, was used in the analysis. Initially, audio recordings of focus group discussions and interviews were transcribed into written form and checked for accuracy. The transcripts were then read several times, guided by the research question and the findings from the literature review, to identify initial codes related

Variable	*f*	%
Gender		
Male	22	81.48
Female	5	18.52
Age		
20–25	15	55.56
25–30	10	37.04
>30	2	7.41
Highest educational degree		
Bachelor	25	92.59
Master	2	7.41
Employment status		
Employee	14	51.85
Unemployed	12	44.44
Student	1	3.70

Source: By authors

Table 1. Lifelong learner participant demographics

to the challenges in SRL and associated needs for SRLA. Following the initial code grouping, the themes were refined, combined or divided in the next stage. A series of revisions and modifications were made to the themes as new information emerged during this stage. During data analysis, a conclusion is reached when it appears that no new themes emerged from the data, and the themes seem to have captured the essence of that data. In the final stage, the themes were elaborated on in detail, and evidence of the themes was provided by relevant quotes from the participants.

4.3 Lifelong learners' self-regulated learning challenges and desirable learning analytics features

Understanding learners' expectations of SRLA is essential for meeting their needs. This study examines the challenges of learners and their expected features and subfeatures of SRLA in the different phases of SRL, namely, forethought, performance and self-reflection phases. The results of the thematic analysis on lifelong learners' focus group discussions and teachers' semistructured interviews are presented in Table 2, which summarizes lifelong learners' voices on SRL challenges and needs, and desirable features and subfeatures for SRLA. The frequency of occurrence and examples of statements for each theme are reported in Appendix 2.

Each SRL phase is reported with associated challenges and needs as well as desirable features and subfeatures. Forethought is an important part of SRL, and it involves planning and preparation of learning activities (Zimmerman, 2002; Zimmerman and Moylan, 2009). In this phase, learners anticipate features that will assist them in understanding tasks, setting goals and planning their learning journeys. It includes information and visualizations of the learning path, instructions for tasks and end goals, as well as personalized recommendations tailored to the individual's motivations. As part of this phase, a comprehensive and engaging dashboard will be needed to set effective goals and plans:

> Group 7 – Student 3: "I start making a plan and strategy regarding what I needed to learn day by day. Sometimes, I'm confused to plan the roadmap, like what to learn first. There are so many resources on the internet, but I need a guide on what I need to learn first and how far. Fortunately, after I joined the Bootcamp, I get guidance. I also need the roadmap to keep me motivated and pressured so I will not procrastinate."

> Teacher 1: "It can be applied in the learning dashboard. I imagine it can be like a timeline or milestone which can show two dots. The first dots can be the general milestone that they need to achieve. The other dots show where they are now. So, it can be exciting that we can see where we are currently. So, this is other than the reminder notifications. It can show the end-to-end."

During the performance phase, learners need features that will help them manage their time, monitor their progress, seek information and receive help and support. This includes task and time management, real-time monitoring, help-seeking, stimulating interests and excitement and rehearsing and constructing knowledge. The challenges in this phase include managing time, tracking progress, efficiently accessing information and receiving the required support:

> Group 5 – Student 2: "[. . .] So, they know their progress each day and accumulate to each week, each chapter, and so on. We can see the tracker, progress, and report. It can be similar to the apps that we usually use to exercise at the gym. We can see the graph for each week, each day, and month. We can see whether it decreases or increases. If it increases, we can set it to keep on that pace. If it decreases, we can reflect, maybe we need to adjust our learning method or why am I being like this, what the cause is, is it because of my condition during the study, or any other personal problem?"

ID	Challenges and needs	Desirable features	Desirable subfeatures
Forethought phase: task analysis and self-motivation beliefs			
C1	Challenges in setting goals and planning. Need for having a comprehensive and engaging visualization dashboard	Understanding the task, setting the goal and planning	Information and visualization of the: 1) general learning path and end goal; 2) task instruction and criteria
C2	Challenges in exploring their motivational factors to set motivating goals and plans. Need for analytics and personalized recommendations based on own motivational factors	Personalized recommendation based on the motivational factors analytics	1) Learning interest; 2) initial level of capabilities; 3) outcome expectancies and goal orientation for future career
Performance phase: self-control and self-observation			
C3	Challenges in time management and task prioritization. Need for information dashboard, prompts and reminders	Task and time management	1) Information for time estimation, schedule and prioritization; 2) prompts to break down the goals; 3) reminder notifications for the target, task and deadline
C4	Challenges to easily record and track the learning activities and progress to motivate performance. Need for various data to be recorded, tracked and feasible	Real-time monitoring	Recording and tracking: 1) learning activities; 2) progress of learning goals; 3) enable to observe peer's learning activities progress
C5	Challenges in getting the required social support. Need for recommendations on whom and how to access them anytime they need, and support for psychological safety	Help-seeking	1) Recommendation and access for connecting to resourceful experts or peers; 2) function to support psychological safety
C6	Challenges in regulating emotion and motivation. Need for analytics features for gamification and personalized motivational notifications	Stimulating interests and excitement during learning	1) Gamification elements; 2) personalized notification for motivational messages
C7	Challenges in constructing new knowledge. Need for prompts and reminders to rehearse information and stimulate self-learning	Strategy to rehearse knowledge	1) Prompt and direct feedback to rehearse information; 2) stimulate self-learning; 3) reminders to review and revisit materials
Self-reflection phase: self-judgment and self-reaction			
C8	Challenges in self-evaluating objectively and comprehensively to keep being adaptive. Need for analytics dashboards and improvement recommendations based on multiple standards	Self-evaluation analytics based on various standards and recommendations for adaptive improvements	1) Certain targeted output criteria; 2) group performance without competition aspects; 3) own standards or track record; 4) review from the experts; 5) review from peers or other references; 6) recommendation on future improvement
Ethics and data preferences			
C9	Concern about sharing their personal data. Need for information on data privacy, transparency and security	Trustworthy information	1) Data privacy; 2) data transparency; 3) data security

Source: By authors

Table 2. Lifelong learner voices on self-regulated learning challenges and needs

> Teacher 3: "[. . .] motivation also plays a role. For example, I have a student that didn't come from a technology background. Her motivation is enough to join the course in the beginning, but not enough to drive her until graduation. So, the motivation needs to be updated frequently along the learning journey. For example, actions to provide encouragement and asking questions to check up on their conditions. Those are impactful for the students. . .So, I think motivational encouragement should not only available in the beginning but also be provided until the end of the learning journey."

The self-reflection phase requires features that will help learners evaluate their performance and make adaptive improvements. This includes self-evaluation analytics based on various standards and recommendations for improvement. The challenges in this phase include objectively evaluating performance and making adaptive improvements:

> Group 4 – Student 1: "A summary of score to show our performance progress, like what things we still need to improve and what we have been good at."

> Teacher 2: "[. . .] Usually, the challenge is in how they try to acquire data to help them evaluate themselves. Because to evaluate yourself, you need to be able to see from several perspectives [. . .] [. . .] They tend to also see only from one factor [. . .]"

Finally, ethics and data preferences require features that ensure the information is trustworthy and protect the privacy of the learner's data. This includes data privacy, transparency and security. The challenges in this phase include concerns about sharing personal data and the need for information on data privacy and security:

> Group 5 – Student 3: "Personally, as long as, we were asked for consent in the beginning on what kind of data and for what purpose, I think I'm okay if it is for the purpose of the learning analytics."

> Teacher 2: "Based on my understanding, I think there are two keys which are permission and personal data. It is better to not include personal data and for the permission, we stated clearly what data that will be acquired and what will be used. So, this is to protect privacy. But, we need to be very clear on what will be acquired and what it will be used for."

In conclusion, learners expect SRLA to provide a comprehensive and engaging dashboard with features that support each phase of the learning process, from understanding the task to evaluating performance and ensuring data privacy. These features should help learners manage their time, monitor progress, seek information, receive help and support, evaluate performance and make adaptive improvements while ensuring that the information they use is trustworthy and protects their privacy.

5. Conceptualization of design principles for self-regulated learning analytics for lifelong learners

The conceptualization of design principles for SRLA was informed by the evidence gathered for lifelong-learner and teacher voices (C1–C9 in Table 2) in alignment with SRL theory (Zimmerman, 2000), and guided by the established design principles for generic LAIS (Nguyen *et al.*, 2021) (see Figure 1). The conceptualized design principles were also iteratively evaluated and refined through expert assessment. The conceptualization centers on the activities that the system should afford for addressing learners' needs as well as promoting SRL to enhance their learning outcomes.

According to Nguyen *et al.'s* (2021) principle of actionable information, LAIS "should have features that allow for the reporting of actionable information about learners and their learning" (p. 555). Our findings reported that learners need features to keep track of their

learning progress toward personal goals and objectives (C1–C4). Importantly, the lifelong learners in this study highlighted the need for personalized recommendations based on their own motivational factors (C2). Accordingly, we argue that SRLA should be able to provide learners with personalized information and visualizations to self-monitor their learning process and prepare for the planned outcomes; thus, the first initial design principle [Init. design principles (DP)] is as follows:

5.1 Init. DP1. Principle of personalized monitoring

SRLA should provide personalized features for learners to self-monitor, self-track and rehearse their learning process toward the planned goals.

With LA, learners can receive personalized recommendations based on their learning interests, capabilities and outcome expectations (Nguyen *et al.*, 2018; Van Schoors *et al.*, 2021). As a result, learners can set more meaningful and achievable learning goals, and make more informed decisions about their futures. Furthermore, aligning learners' individual learning progress with their own learning goals could also motivate them to better engage in learning. Motivation plays a significant role in SRL as it drives individuals to take initiative and actively engage in the learning process (Zimmerman and Moylan, 2009).

As a result of our findings, learners need analytics to regularly engage them in learning with features that stimulate their interests and motivate them to maintain their learning progress (C3, C6, C8). Accordingly, our initial DP2 was defined as the principle of continuous engagement that recommends SRLA to provide personalized features to stimulate interests and excitement to boost their motivation and engagement in learning. Nevertheless, Nguyen *et al.* (2021)'s principle of information timeliness recommends LAIS to deliver analytics at the right time for its maximum impact, and learning sciences and decision sciences can provide insight into the best way to design the time latency between data collection and reporting.

5.2 Init. DP2. Principle of continuous engagement

SRLA should provide personalized features to stimulate interest and excitement to maintain learners' engagement in learning.

A key component of SRL is reflection, which enables learners to assess their learning experiences and use that information to guide future learning (Zimmerman and Moylan, 2009). It is a process of introspection in which learners examine their own experiences, thoughts and emotions. Nevertheless, learners can also reflect through the peer reflection process in which learners reflect on their own experiences and then share their insights and perspectives with their peers for discussion and further reflection. In addition to self-reflection and peer reflection, reflection on feedback from other sources, including LA tools, can also be a form of reflection. In this study, lifelong learners reported challenges to self-evaluate objectively and comprehensively to remain adaptive (C8). It is suggested for SRLA to involve features for acquiring or generating feedback from several sources, including individual and collective feedback from peers and experts.

5.3 Init. DP3. Principle of critical reflection

SRLA should deliver formative and summative feedback based on different standards and from different stakeholders for adaptive improvements.

Research has shown that social interactions and support could significantly influence learners' SRL (Kwon *et al.*, 2014). Our findings from learners' focus group discussions emphasized the need for SRLA to offer access to social and psychological support during the learning process (C5). This resulted in our proposed principle of social support as follows:

5.4 Init. DP4. Principle of social support

SRLA should recommend and provide access to social and psychological support.

The principle of social support posits that SRLA systems should extend beyond mere academic metrics to include recommendations and resources for social and psychological support. This extension appears well-founded, given the gaps in the current literature. Traditional SRL theories (e.g. Zimmerman, 2000) predominantly focus on cognitive elements such as planning, time management and meta-cognition. Likewise, existing SRLA systems, as described by Winne (2017), have largely been confined to these dimensions. However, this narrow focus overlooks the significance of affective and social elements, which have been emphasized in broader educational psychology literature. The inclusion of social support aligns with Vygotsky and Cole's (1978) constructivist theories, Bandura's (2001) social cognitive theory and Hadwin *et al.*'s (2018) SRL model. Empirical evidence from Chen (2022) and Järvelä *et al.* (2015) supports this, showing improved student engagement and well-being. However, ethical challenges related to data privacy (Nguyen *et al.*, 2023; Slade and Prinsloo, 2013) and measure accuracy (Ifenthaler and Widanapathirana, 2014) should be carefully considered in future implementations. Accordingly, DP5 was conceptualized to address the ethics and privacy aspects of SRLA as follows:

5.5 Init. DP5. Principle of ethics and privacy

SRLA should provide anonymity and transparency for personal data and protect data against accidental or unlawful destruction or accidental loss, alteration, unauthorized disclosure, or access.

The principle of ethics and privacy calls for SRLA to emphasize anonymity, transparency and robust data protection. This principle complements existing literature that critiques the lack of ethical considerations in traditional educational analytics systems (Slade and Prinsloo, 2013). The call for anonymity aligns with broader trends in information systems emphasizing user control over personal data (Nguyen *et al.*, 2021), while transparency fosters trust, enhancing the effectiveness of SRLA (Buckingham Shum *et al.*, 2019). Additionally, the explicit focus on data protection addresses the real-world risks of data breaches, aligning with regulations like the General Data Protection Regulation (GDPR) in the European Union. In sum, this principle provides a crucial ethical framework for SRLA but demands ongoing commitment to ethical vigilance to adapt to emerging challenges.

6. Evaluation of the design principles for self-regulated learning analytics for lifelong learners

Four experts in the domains of LA and SRL were invited for the evaluation of both learner needs and the conceptualized design principles for SRLA. Three of the experts are working in the field of learning sciences (Expert A: Female, 12 years of experience; Expert B: Female, six years of experience; and Expert C: Male, 15 years of experience), while the other one is in the field of information sciences (Expert D: Female, eight years of experience). All the experts have published scientific papers within the domains of LA and SRL. They are presented with the conceptualized design principles for SRLA and the findings from learner focus group discussions and teacher interviews. After their own reading time, the

researchers first walked them through the learners' needs and their desirable features for SRLA. The experts were asked to provide their assessment based on the provided evaluation criteria (adopted from Venable *et al.*, 2012; see above). They were then requested to evaluate whether the set of conceptualized design principles for SRLA has captured all learner needs, and any improvements needed for design principles to serve as useful guidance for SRLA design and development. The expert evaluation sessions lasted between 40 min and 60 min and were videotaped for later examination in evaluating and refining the design principles for SRLA. All the presented learner needs and design principles were sent to the expert after the evaluation sessions for potentially additional examination and feedback via emails.

In the evaluation, all four experts agreed with the importance of this principle of personalized monitoring (DP1 evaluated). Regarding DP2, a learning sciences expert (Expert A) has raised concerns about "continuous engagement" because excessive engagement in learning can be harmful to learners. Studies have pointed to the phenomenon of "academic burnout," where constant engagement with educational tasks may lead to stress, emotional exhaustion and reduced academic performance (Schaufeli *et al.*, 2002). Furthermore, Kirschner and Karpinski (2010) found that higher engagement in online learning environments could also result in decreased time for other crucial activities, including physical exercise and social interactions, which are essential for holistic well-being. Therefore, while engagement is often considered a positive metric in SRLA, there is a need to balance it with considerations for the learner's overall health and well-being. Appropriately, after carefully reviewing the issue, we revised the initial DP2 to focus on persuasive motivation for SRLA to stimulate learning interests:

6.1 Revised DP2. Principle of persuasive motivation

SRLA should provide personalized features to stimulate interest and excitement to boost their motivation and engagement in learning.

This revised DP2 finds grounding in self-determination theory, which posits that meeting individual needs for autonomy and competence can boost intrinsic motivation (Deci and Ryan, 1985). For instance, the use of "gamification" elements has demonstrated the potential to increase both motivation and engagement in learning contexts (Deterding *et al.*, 2011). Therefore, incorporating persuasive elements into SRLA could serve as a powerful strategy to enhance learner motivation and engagement, albeit with a mindful approach to avoid potential pitfalls such as excessive engagement.

Interestingly, regarding DP3, evaluation with the experts raised a critical discourse about the role of SRLA in improving and/or promoting learners' SRL. Expert B from learning sciences questioned about the undesirable consequences of SRLA in establishing learners' reliance on technology for sustaining SRL activities. It is recommended that SRLA should consider a scaffolding approach in developing learners' SRL skills. Recent research has highlighted the importance of adaptive scaffolding in supporting SRL (Song and Glazewski, 2023). On the other hand, although Expert D from information sciences agreed with these side effects of SRLA, Expert D argued for the nature of living with technology in the age of artificial intelligence (AI). The augmentation was provided for the fact that many learning activities and processes are now cooperating with the use of technology, such as Google or Microsoft 365, which extends beyond the classroom to include daily life tasks that are integral to SRL. For instance, planning and time management – key components of SRL as outlined by Zimmerman (2000) – are often facilitated through digital tools like Google Calendar or Microsoft Outlook. These platforms not only assist in organizing academic deadlines but also help manage personal commitments, thereby enabling a holistic approach

to self-regulation (Koehler and Mishra, 2005). Thus, the fusion of SRL activities with ubiquitous technology platforms highlights the increasingly blurred boundaries between educational and everyday digital tools, reinforcing the need for SRLA to be adaptable and integrated across multiple contexts. Future studies on the current topic from different philosophical perspectives are, therefore, recommended.

All the experts reached a consensus on DP4 and also referred to recent literature that highlighted the importance of emotional regulation (e.g. Järvenoja *et al.*, 2019) and its support. They also shared an agreement on the principle of ethics and privacy that advocates SRLA to anonymous and transparent handling of personal data, with protection against unauthorized access, destruction, alteration or disclosure. It is important to consider questions, such as whether the collection and use of learner data are necessary, whether the data is being used in a fair and transparent manner, and whether the benefits of the data use outweigh any potential detriment. The ethical and privacy aspects of LA remain challenging (Ladjal *et al.*, 2022), yet we hope that the findings from this study can contribute to the discussion to push forward the design and development of trustworthy LA systems.

Table 3 summarizes the final five design principles for SRLA as the output from our TPDM. The design principles offer prescriptive knowledge about the design of SRLA systems.

7. Discussion and implications

The importance of lifelong learning along with professional development has never been greater than it is today in a world that is fast-changing. SRL has been a key skill for successful lifelong learning (Molenaar, 2022). By providing learners with insights and recommendations based on their learning activities and progress, LA tools and technologies aim to facilitate and enhance SRL (Winne, 2017). The integration of LA into SRL can help lifelong learners make informed decisions about their learning activities, monitor their progress and evaluate their performance. Although research has provided insightful understandings of SRL processes and LA support for SRL, previous studies have been mostly conducted in the context of K-12 and higher education (Heikkinen *et al.*, 2022). Up to now, far too little attention has been paid to SRLA targeting lifelong learners. This study thus attempts to fill a noteworthy gap by

Table 3.
Design principles for self-regulated learning analytics (SRLA) for lifelong learners

#	Design principle	Specifications of design principle for SRLA
DP1	Principle of personalized monitoring	Should generate personalized information and visualization for learners to self-monitor and rehearse their learning process toward the planned goals
DP2	Principle of persuasive motivation	Should provide personalized features to stimulate interest and excitement to boost their motivation and engagement in learning
DP3	Principle of critical reflection	Should deliver formative and summative feedback based on different standards and from different stakeholders for adaptive improvements
DP4	Principle of social support	Should recommend and provide access to social and psychological support
DP5	Principle of ethics and privacy	Should provide anonymity and transparency for personal data and protect data against accidental or unlawful destruction or accidental loss, alteration, unauthorized disclosure or access

Source: By authors

examining the challenges and needs of lifelong learners in SRL (*RQ1*, Table 1) to inform the design and development of SRLA (*RQ2*, Table 2).

Human-centered LA has grown rapidly in recent years and has the potential to support learners in developing SRL skills and improving their academic performance. In spite of these benefits, it has been questioned about how to consider the voice of learners more into the design and development of human-centered LA (Buckingham Shum *et al.*, 2019). In this study, we present an approach for TPDM (Figure 1) that addresses the well-recognized concerns about the alignment between the needs of the learners and the design of LA tools and systems. Learners' learning preferences are not always aligned with teachers' pedagogical intentions or successful learning theories. Our TPDM methodology offers guidance for integrating and evaluating learner needs into the design of theory-grounded human-centered LA.

TPDM approach offers a comprehensive framework that combines viewpoints from various key players in the educational process. approach distinguishes itself from existing methodologies primarily through its comprehensive integration of perspectives, ranging from frontline users like lifelong learners and teachers to theoretical frameworks and expert evaluations. Traditional approaches, such as user-centered design (Norman, 1986) or participatory design (Schuler and Namioka, 1993) often focus more narrowly on user involvement or the inclusion of specific stakeholder groups, respectively, but may lack a structured integration of theoretical constructs. TDPM not only incorporates experiential insights from these stakeholders but also synthesizes foundational concepts from learning theories and design theories to inform its methodology. The inclusion of these nascent theories provides a structured backbone, allowing for data-driven adjustments and refinements in the design process (Baskerville *et al.*, 2018; Heinrich and Schwabe, 2014). Finally, the TDPM approach is subject to evaluation by experts in the field, adding a layer of rigor and validity to the outcomes. This multilayered integration serves to produce more contextually relevant, empirically supported and theoretically robust educational interventions or tools, therefore, enhancing its applicability and impact.

In terms of research impact, TDPM contributes to the empirical rigor by synthesizing insights across a diverse set of stakeholders and theories. It addresses gaps in existing frameworks that may be overly reliant on a single theory or stakeholder perspective. Thus, TDPM fosters a more nuanced and comprehensive understanding of learning contexts, providing fertile ground for interdisciplinary research. For practical applications, TDPM's multifaceted approach ensures that educational interventions or tools are not only theoretically robust but also contextually relevant and practically effective. By incorporating real-world insights from lifelong learners and teachers and subjecting the design to expert evaluations, TDPM enhances the usability and effectiveness of the final product. This broadens the research artefact's appeal and adaptability, making it more likely to be adopted in diverse learning environments.

Our findings also suggest some practical implications for promoting SRL in professional development programs. Taking control of an individual's learning process is an essential element of SRL, which leads to improved outcomes and greater satisfaction (Theobald, 2021). However, it is challenging for lifelong learners in professional development programs to manage their learning time while learning is often not their sole or even main occupation. Accordingly, it is crucial to provide lifelong learners with support for time management as well as to keep up their learning motivation. The results of this study can also shed light on developing SRLA systems to address lifelong learner needs.

The results of this study indicate that it can be helpful to learners to stay motivated by real-time monitoring and tracking of their learning activities and progress toward their personal goals and objectives. The use of motivational notifications and gamification can also aid in stimulating interest and excitement about learning. Previous research suggests

that gamified approach embedded with SRL support can leverage students' intrinsic motivation and lead to better learning (Qiao *et al.*, 2022). In line with prior studies, our findings imply the importance of the self-regulated gamified approach for lifelong learning.

Furthermore, LA has been the subject of controversy for years (Pargman and McGrath, 2021). LA design and use are hampered by a lack of evidence and guidelines for practical ethics from end-users' perceptions and assessments. Triangulating data collected from both lifelong learners and teachers, this study informs learners' ethical concerns, relevant data and the conditions in which they are willing to share for SRLA. Learners in this study reported concerns regarding the security, privacy and transparency of their data, which is consistent with the literature. Nevertheless, as long as the LA process is secure and transparent without using sensitive personal information (e.g. income, health, etc.), lifelong learners expressed a high willingness to share their data for SRLA that could support their learning effectively.

It is important to note that this study is limited to analyzing data from a single group or context. This can limit the generalizability of the findings that may not be applicable to other settings or cultural contexts. Further research may conduct multisite studies or comparative studies in different contexts to validate the generalizability of our findings. Furthermore, the limitation of thematic analysis lies in its susceptibility to researcher bias and its challenges in managing large or context-rich data sets, which can compromise the depth and validity of the study (Braun and Clarke, 2006; Guest *et al.*, 2011). Despite these limitations, the method's adaptability and ease of use make it an effective approach for eliciting and understanding the varied viewpoints of stakeholders. Another limitation of this study is related to the small sample size of teachers and experts involved in this study. Although teacher voices and expert opinions were only applied to evaluate the learner needs, the small sample sizes may not provide a comprehensive validity and generalizability of the findings. Notwithstanding the relatively limited sample, we gained great insights from the triangulation of results from learners, teachers and experts.

8. Conclusion and final remarks

In the age of AI, the ability to self-regulate learning for lifelong learning is increasingly becoming important for individuals who want to remain relevant and competitive in the workplace. As an example, the recent release of OpenAI's Chat-GPT serves as a reminder of the importance of self-regulated lifelong learning as it demonstrates the potential of AI to automate job tasks previously performed by humans. Individuals must constantly learn new skills and adapt to new knowledge due to the rapid pace of technological advancement and the constantly changing job market. Lifelong learners can stay up to date with the latest developments in their field by taking responsibility for their own learning through SRL. Embracing human-centered LA can contribute significantly to supporting lifelong learners' SRL. The proposed approach for TPDM will allow advanced integration of learning sciences and design science research into the development of effective and trustworthy human-centered SRLA systems for lifelong learners.

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Appendix 1

Phase	Guiding questions/topics
Opening	• Introduction • Brief based on participants information sheet
Forethough phase	• What are the challenges that you feel when you try to understand the learning tasks? • What kind of support that can be helpful for you to understand the learning tasks? • In terms of learning analytics features to assist you in understanding the learning tasks, how do you think that support could be designed? • What kind of data are you willing and NOT willing to share to receive the support that you need to understand the learning tasks? • What are the challenges that you feel when you try to create a learning goal and plan? • What kind of support that can be helpful for you to create a learning goal and plan? • In terms of learning analytics features to assist you in creating a learning goal and plan, how do you think that support could be designed? • What kind of data are you willing and NOT willing to share to receive the support that you need to create a learning goal and plan?
Performance phase	• What are the challenges that you feel when you try to implement your learning tactics and strategies? • What kind of support that can be helpful for you to implement your learning tactics and strategies? • In terms of learning analytics features to assist you in implementing your learning tactics and strategies, how do you think that support could be designed? • What kind of data are you willing and not willing to share to receive the support that you need to implement your learning tactics and strategies?
Self-reflection phase	• What are the challenges that you feel when you would like to evaluate your learning process and decide on any adaptation needed for the future learning process? • What kind of support that can be helpful for you to evaluate your learning process and decide on any adaptation needed for the future learning process? • In terms of learning analytics features to assist you in evaluating your learning process and deciding on any adaptation needed for the future learning process, how do you think that support could be designed? • What kind of data are you willing and NOT willing to share to receive the support that you need to decide on any adaptation needed for the future learning process?
Closing	• Closing statement

Source: By authors

Table A1.
Focus group discussion questions for learners

Phase	Guiding questions/topics
Opening	• Introduction • Brief based on participants information sheet
Forethough phase	• What are the common challenges that you observe from your students to understand the learning tasks? • What kind of support can be helpful for your students to understand the learning tasks? • In terms of learning analytics features to assist your students to understand the learning tasks, how do you think that support could be designed? • What kind of data that you think will and will NOT be ethical to be acquired from the students to receive the supports that they are needed to understand the learning tasks? • What are the common challenges that you observe from your students to create a learning goal and plan? • What kind of support can be helpful for your students to create a learning goal and plan? • In terms of learning analytics features to assist your students to create a learning goal and plan, how do you think that support could be designed? • What kind of data that you think will and will NOT be ethical to be acquired from the students to receive the supports that they are needed to create a learning goal and plan?
Performance phase	• What are the common challenges that you observe from your students to implement their learning tactics and strategies? • What kind of support can be helpful for your students to implement their learning tactics and strategies? • In terms of learning analytics features to assist your students to implement their learning tactics and strategies, how do you think that support could be designed? • What kind of data that you think will and will NOT be ethical to be acquired from the students to receive the supports that they are needed to implement their learning tactics and strategies?
Self-reflection phase	• What are the common challenges that you observe from your students to evaluate their learning process and decide on any adaptation needed for the future learning process? • What kind of support can be helpful for your students to evaluate their learning process and decide on any adaptation needed for the future learning process? • In terms of learning analytics features to assist your students to evaluate their learning process and decide on any adaptation needed for the future learning process, how do you think that support could be designed? • What kind of data that you think will and will NOT be ethical to be acquired from the students to receive the supports that they are needed to decide on any adaptation needed for the future learning process?
Closing	• Closing statement

Table A2.
Interview questions for teachers

Source: By authors

Code	Challenges and needs (CN)	Examples	% Learners	% Teachers
Forethought phase: task analysis and self-motivation beliefs				
C1	Challenges in setting goals and planning. Need for having a comprehensive and engaging visualization dashboard	Students (Group 5): "To make a plan, we need to get ideas on what the output would be. Maybe we can break down the method. So, the point is, to execute something, we need to know what the output should be. As a student, what output is expected from my study, what would it be used for, and how would it help me in the future?" Students (Group 7): "I start making a plan and strategy regarding what I needed to learn day by day. Sometimes, I'm confused to plan the roadmap, like what to learn first. There are so many resources on the internet, but I need a guide on what I need to learn first and how far. Fortunately, after I joined the Bootcamp, I get guidance. I also need the roadmap to keep me motivated and pressured so I will not procrastinate" Teachers 1: "One of their difficulties that I observe is because they don't really have the sense of 'where are they now' and 'where they should be. So, it kind of needs visualization and feedback for them regarding the end-to-end milestone, where they are now, what they are aiming for currently, and what they are studying… I feel that they still need to define their 'end-in-mind.' They need to define what their 'end-in-mind' is. Sometimes, they don't have that goal and just do whatever it is. So, when they don't have their own end goal, they only rely on our expectations"	81 (22)	100 (5)
C2	Challenges in exploring their motivational factors to set motivating goals and plans. Need for analytics and personalized recommendations based on various types of motivational factors	Students (Group 4): "As someone with no background in the technology field, I feel confused about what I should take, for example, there is Data Science, but also Business Intelligence Analyst and Business Intelligence Engineering. It was time-consuming to seek and compare information here and there" Students (Group 8): "Okay, maybe a little bit of background. I was not coming from Digital Marketing or any other IT-related field. So, in the beginning, I even was confused about what course I should take" Teachers 2: "There are two characteristics of students which are the one who studies because of their own initiatives and the one that is assigned either by their company or scholarship. So, one has more internal motivation and the other one has more external motivation. It is because those two types of students always have different challenges. The first category of students usually has no big issues in the beginning because they have done their	93 (25)	100 (5)

(*continued*)

Table A3.
Lifelong learners' challenges and needs for self-regulated learning

Table A3.

Code	Challenges and needs (CN)	Examples	% Learners	% Teachers
		research. They have known or got ideas of what the task would be. The bigger challenge comes from the second type of student. They have not done their research and have no ideas regarding the goal of the courses and misunderstand. They also expect that the learning process in this Bootcamp will be the same as the conventional school that they know. Meanwhile, in our Bootcamp, it will not be like that. They will be required to also do self-learning. When it doesn't meet their expectation, it will demotivate them. But, the instruction that we provide is actually clear enough as long as they read it. The first type of students is sometimes worried about whether they choose the right course or whether they are able to learn this competency now. So, they need assurance for their self-efficacy. They need assurance that they can get that goal here" Teachers 3: "However, sometimes the students can hardly measure their own capabilities. 'Can I be like him in 1 year?' This requires a point of view from others to help them make a realistic target. It is required to prevent students from easily giving up along the way. It needs a point of view from others to help them create realistic goals, for example, 'He can achieve it in 1 year, then maybe I can set my target to achieve it in more or less 10 months'"		
Performance phase: self-control and self-observation				
C3	Challenges in time management and task prioritization. Need for information dashboard, prompts and reminders	Students (Group 3): "I would like to add a little bit to that. I also experienced a similar thing. So, I feel like the duration to finish the challenge (the task) is actually quite long, but I feel like I don't have enough time to do it. When the workload is a lot, sometimes we also need time to take rest. We tend to procrastinate on doing the challenge. On the other side, the timeline for completing the challenge is also quite tight. In the end, I just focus on finishing it but not doing my best"	85 (23)	100 (5)

(*continued*)

Table A3.

Code	Challenges and needs (CN)	Examples	% Learners	% Teachers
		Teachers 3: "From the students' side, sometimes we don't know how much time they can dedicate themselves to self-learning outside our class schedule. It is because mostly they are also busy with many other things. Different students have different prioritization. It impacts their time to practice or do the task by themselves even though I see that the students are smart and have potential. I believe if they dedicate their time for one or two hours, they would be able to perform well. Back to the self-regulated learning concept, they should be able to manage their priority so their learning process will also be managed as their priority"		
C4	Challenges to easily record and track the learning activities and progress to motivate performance. Need for various data to be recorded, tracked and feasible	Students (Group 9): "To help me execute consistently, I need to have a sense of progress. It can show the percentage of my progress" Students (Group 7): "Maybe this is not a challenge but I would like to be able to measure myself. I would like to know my speed in learning. If we learn but have no measurement to track the progress, I sometimes feel lost, like things that maybe I don't need to learn too much, I keep learning them even though maybe it is not really needed in the company later. I'm afraid that I'm off the track. I need monitoring" Teachers 2: "In the middle of the road, they tend to forget their initial goal. For example, there is one student who has a goal to learn data science for improving his village. But, in the middle of the road, he tends to compare himself with his peers only. If he remembers and goes back to his goal, he should stick to his goal and when he learns in class, he should use his goal to be a case study for discussion with his facilitator. He tends to lose his way and forget his initial mission. It is actually not fully wrong. But it is not ideal to keep changing their goals in the middle of the way without actually evaluating their strategies or methods. They tend to give up without trying more. Or, they already lose confidence and try to follow other people, without reflecting on themselves. They are not evaluating, like, how much time they spend learning or reading the materials, whether they optimize the Q&A session during class, how much time I do the practice, and what my learning strategies are. To better evaluate ourselves, we need to see all those factors as well"	67 (18)	100 (5)

(*continued*)

Table A3.

Code	Challenges and needs (CN)	Examples	% Learners	% Teachers
		Teachers 4: "It is quite obvious that the students that tend to be successful in their studies are those who are active in asking questions and discussion sessions or forums. I also see from their report, those who tend to be successful show progress based on the facilitator's feedback. And the most significant things are they always attend class"		
C5	Challenges in getting the required social support. Need for recommendations on whom and how to access them anytime they need, as well as support for psychological safety	Students (Group 9): "If I have any questions, I would like to ask the facilitator. So, I don't have any challenges in exploring and learning the information and all the references" Students (Group 3): "I would also like to add. It is true that having a supportive peer is very impacting. We can ask anything without feel hesitate" Teachers 2: "In the end, there are some people who are not seeking help and, in the end, just fail, but there are some that come to us to see for help"	78 (21)	80 (4)
C6	Challenges in regulating emotion and motivation. Need for analytics features with gamification elements and personalized motivational notifications	Students (Group 1): "Maybe it is more about the excitement. Let's say you don't understand the material, but if you're excited, it will still be fun" Students (Group 2): "Therefore, I think it can be done also in the middle of the journey so it can help to maintain motivation because usually in the middle of the process, we start to get bored, feel demotivated, and it becomes more challenging" Teachers 3: "Other than that, motivation also plays a role. For example, I have a student that didn't come from a technology background. Her motivation is enough to join the course in the beginning, but not enough to drive her until graduation. So, the motivation needs to be updated frequently along the learning journey. For example, actions to provide encouragement and asking questions to check up on their conditions. Those are impactful for the students. She said by herself that she once thought to drop out of the course but because there was the LQ team (Learning Quality or students support team) and me as the facilitator that provide her with encouragement, it helped her to continue her study. So, I think motivational encouragement should not only available in the beginning but also be provided until the end of the learning journey" Teachers 2: "they also might need some human aspects, like their grown mindset, self-concept, their readiness to learn online, and their perspective on career and learning. I don't know yet how to support them in the form of technology. For example, they can see their progress and they might judge	48 (13)	80 (4)

(*continued*)

Code	Challenges and needs (CN)	Examples	% Learners	% Teachers
		themselves as bad. After we provide recommendations, we need something to make sure or encourage them to do the recommendation. For example, there can be a sentence 'it's okay to fail. We can try again because intelligence is not something given. We need to keep progressing. So, let's try again!' So, after they have the analytics and get the recommendation, there should be an effort for them to take the action. The factors are varied. They might need that kind of supportive encouragement, or some of them might need a buddy to help them or to make them feel not alone. So, these kinds of factors, if not considered, might make those features not work because they can feel incapable at a certain point. Yes, it is something to help them regulate their emotion as well. The emotional aspect is the hardest thing to be touched. Maybe making this into gamification might help but maybe not work for all people as well"		
C7	Challenges in constructing new knowledge. Need for prompts and reminders to rehearse information and stimulate self-learning	Students (Group 10): "Yes, because there are a lot of materials and sometimes, we can forget what we have learned before. Maybe, like in 2 or 3 months later we may forget so it can be helpful" Students (Group 6): "Yes, I feel a need to have something, like a comprehension check on some parts. It can help to align our understanding before we continue to the next part. I don't know maybe it has to be in the form of a quiz" Teachers 1: "For example, they also can put their notes on their understanding of the class. If they don't fill it, we don't know whether they have the understanding or not. So, this kind of note can be more reflective notes. It can also help them rehearse or repeat the information" Teachers 4: "The most frequent cases are they have difficulties in working on the challenge (the tasks). If we break down the cases, there are several problems that cause that. First, it can be because their basic knowledge is not strong yet. They feel that they have not mastered the previous chapter yet but they already need to work on the next challenge (tasks)"	74 (20)	100 (5)
Self-reflection phase: self-judgment and self-reaction				
C8	Challenges in self-evaluating objectively and comprehensively to keep being adaptive. Need for analytics	Students (Group 1): "The difference between formal school or college is, in school, maybe people feel trapped in the formal routine, but in Bootcamp, people tend to have similar goals, which is to achieve the mastery of the skills. Not to achieve the best score, or become better than other people. So, there	89 (24)	100 (5)

(*continued*)

Table A3.

Table A3.

Code	Challenges and needs (CN)	Examples	% Learners	% Teachers
	dashboards and improvement recommendations based on multiple standards	should be no element of competition when it comes to Bootcamp for professionals. Thus, I feel like the more important thing is to empower the feasibility of your learning curve" Students (Group 4): "However, what I need most is to know what can be improved from my task results just like what has been mentioned before" Students (Group 7): "I feel my challenge is more because of denial. My brain sometimes denies me, for example, I know that my method is still wrong but I deny it by blaming that this is just too difficult. I need something to help me evaluate that, evaluate my method. I try by reviewing my progress, for example, previously I still need to use alt-tab while coding but now I know the algorithm better to code continuously. After that, when I start a new lesson, I tried to implement the same strategy. Turns out, the previous strategy has not been efficient anymore for this part. Turns out, I need to learn the theory again for this part. So, I found that not all strategies can be implemented in all cases. So, I need to keep adapting my coding method" Teachers 1: "They just rely on our standards or requirements. I feel like it is a product of our overall education systems. We are just pushed to always meet the 'standards.' So, we never try to meet 'my standards.' We are never taught or had any reference about that. So, they just would like to meet the standards. Most of all, even all students that I observe, just would like to meet the standards. Maybe, only less than 5didn't show that. I only see that capability only maybe in a few already more mature students, like those who have become an employee. Only a few numbers already have their pre-defined standards so we just need to facilitate or encourage them based on theirs" Teachers 2: "These are based on those who are not succeeding in this case. Usually, the challenge is in how they try to acquire data to help them evaluate themselves. Because to evaluate yourself, you need to be able to see from several perspectives. They tend to not see the wider perspectives. For example, I get a bad score because I don't have an aligned background, to begin with. That's it. Or, they feel that their peers are smarter than them. Even they can blame the environment, like the facilitator, the materials, and so on. They tend to also see only from one factor. This is what usually happens to those who fail in the end. For example, only comparing to standard score or comparing to the		

(*continued*)

Table A3.

Code	Challenges and needs (CN)	Examples	% Learners	% Teachers
		peers only. They are not evaluating, like, how much time they spend learning or reading the materials, whether they optimize the Q&A session during class, how much time I do the practice, and what my learning strategies are. To better evaluate ourselves, we need to see all those factors as well. They tend to jump to conclusions only based on one superficial factor. Then, it breaks their self-efficacy and confidence… Actually, we need to strengthen their self-evaluation so they can stop comparing with others. So, ideally, they can evaluate their own progress. Comparing with others is enough for the beginning only, for example, just to set the ideal examples but after that how to achieve our goal will depend to our own ways. So, we need to strengthen the self-evaluation"		
Ethics and data preferences				
C9	Challenges in having concerns to share their personal data. Need for information on data privacy, transparency and security	Students (Group 1): "I tend to fill in a random way if they require me to provide information that is not relevant. Except, if there is any urgency, even though mostly I will still concern" Teachers 2: "Based on my understanding, I think there are two keys which are permission and personal data. It is better to not include personal data and for the permission, we stated clearly what data that will be acquired and what will be used. So, this is to protect privacy. But, we need to be very clear on what will be acquired and what it will be used for"	81 (22)	100 (5)

Source: By authors

Table A4.
Support features lifelong learners expect from self-regulated learning analytics

Features	Subfeatures	Examples	CN	DP(s)	% Learners	% Teachers
Forethought phase: task analysis and self-motivation beliefs						
Understanding the task, setting the goal and planning	Information and visualization of the: 1) General learning path and end goal	Students (Group 7): "I think the roadmap is very important as the foundation of learning. Maybe the feature can make a well-designed roadmap that is not too rigid. I mean if we think of a roadmap sometimes it is in the form of boxes that show the steps. Maybe, the visualization can be in form, like a tree" Students (Group 5): "I need a big mindmap. We have the syllabus but like in a table sheet. There is also the map version for each topic but it is on each chapter. I'm thinking to have it in the apps that can visualize all the pieces into one map so I can see the helicopter view. And it can be a dashboard for the reading material as well. So, when we click the map, we can see the breakdown of the materials" Teachers 1: "it can be applied in the learning dashboard. I imagine it can be like a timeline or milestone which can show two dots. The first dots can be the general milestone that they need to achieve. The other dots show where they are now. So, it can be exciting that we can see where we are currently. So, this is other than the reminder notifications. It can show the end-to-end"	C1	DP1	81 (22)	80 (4)
	2) Task instruction and output criteria	Students (Group 1): "regarding the instruction. It will help us, as student, to know the success metrics. We usually get the scoring rubric when we do an assessment. If we achieve this kind of comprehension, then it is good. So, the rubric is also helping to set the target, which level we would like to achieve" Teachers 2: "We already have the standard criteria that will be assessed in the end or become the end goal. But, we need to also present the breakdown to be able to achieve that like how many hours you need to spend"			59 (16)	80 (4)

(*continued*)

Table A4.

Features	Subfeatures	Examples	CN	DP(s)	% Learners	% Teachers
Personalized recommendation based on the motivational factors analytics	1) Learning interest	Students (Group 3): "So, I am thinking, in the case of UIUX Bootcamp, it can be divided. If you would like to focus on a career in the UX field, what you can explore, and what the step-by-step is. If you would like to focus more on the UI, what you can do and how to achieve it. It also can show how this Bootcamp correlates to the possible job in the field. From there, the students can set their focus. If I would like to be a UX Researcher, then I need to strengthen myself in this part 1 2 3. That is what I could think of" Students (Group 3): "I totally agree with the ideas. I also think we need additional features after we know our interest and which path we would like to pursue as an aspiration, and also enough information about what the roles do" Teachers 4: "I feel like having various courses option can help to facilitate students finding the suitable course based on their interests. Sometimes, in Full-Stack Web Development course, there are some students that feel that they tend to be interested more in the Backend or Frontend only. I think it would be helpful if there is something like that in the beginning"	C2	DP2	52 (14)	20 (1)
	2) Initial level of capabilities	Students (Group 1): "It will be great if there are some features to match our level of comprehension. If he is already skillful enough, he can be provided with a harder level of challenge. If I am still at the lower level, I can find the challenge in the lower level to help me understand the concept first. So, during the Bootcamp, it feels hard because we only get several tutorial sessions, then we need to study by ourselves. It's not easy to chase the pace" Teachers 4: "It would be great if it is personalized even though I could not imagine how the data behind it. But, it would be great to have it personalized because, in each chapter, the student's capabilities and achievements can be different from one another"			78 (21)	60 (3)
	3) Outcome expectancies and goal orientation for future career journey	Students (Group 3): "It is true that we need a feature that can show us the learning path based on the provided career path. It can be very helpful. I also think we can choose quantitatively based on questions. The score can show our interest tendency to certain jobs that will be suitable to our interests. I feel that I also have experienced something like that. I was confused on what path that I should take. I did not really know what UX Researcher does, or UI Designer. I was still very			67 (18)	100 (5)

(*continued*)

Table A4.

Features	Subfeatures	Examples	CN	DP(s)	% Learners	% Teachers
		beginner in that knowledge. Maybe, there can be two solutions for that. First, the solution can provide detailed information regarding the roles and what they do to give some vision. The second feature is back to the help desk ideas, or like a consultation platform. When you have read the information and you still need more confirmations, your can consult and get some advice on which path you would be better take" Teachers 4: "We can also provide a standard based on a career goal, for example, if you would like to be a Full-Stack Engineer, what do you need to have or what kind of things are required in the hiring process? So, it can be a standard based on real-life practice"				
Performance phase: self-control and self-observation						
Task and time management	1) Information for time estimation, schedule and prioritization	Students (Group 8): "I need to get a clear visualization of how many hours the study would take" Teachers 1: "There are some materials that are directly relevant to the final challenge (final task), but there are some that are only supporting. So, that kind of knowledge needs to be informed to them so they can decide where to focus their energy"	C3	DP1	81 (22)	100 (5)
	2) Prompts to break down the goals	Students (Group 3): "It would be great if there is something like a student's form or student goals that can act like a checklist. For example, to become an expert in UX, you need to understand user flow, have you also understood information architecture yet? So, it will be a checklist. It can be a self-checked list by the students but can be also controlled by the facilitators. So, when the students look like have not mastered the materials yet, the facilitators can provide no checklist for that part and they can help the students with that. This is just like my imagination. So, students can also recall the materials, and know which part that they should work on more, and it will be more feasible to direct their goals" Teachers 2: "My idea is there might be a checklist, for example, to understand A, we need to read the material for this hour… They need to know that they need to do self-learning as well. This will help them to make the learning goal and plan their learning strategies. For example, they are informed that they need to read the materials beforehand, they need to do research and practice on their own, or			59 (16)	100 (5)

(*continued*)

Table A4.

Features	Subfeatures	Examples	CN	DP(s)	% Learners	% Teachers
		they need to learn by themselves before the class so they know what to ask the facilitator during the class. It has to be that detailed because sometimes they don't realize that they need to do that… Another example is from a pregnancy app. In the apps, there is a certain checkpoint. Each week's checkpoint has a breakdown in the form of a checklist. The checklist is broken down into several categories, for example, nutrients. Have we drunk enough water or eat enough vegetables? The next category will be regarding exercise, for example, have you done stretching today? Something like that. And below, you can see how many percentages you have achieved so you can evaluate 'oh, turns out, I lack in nutrients.' This experience is similar to their experience which in this case we have no idea at all about the step-by-step at the beginning. This can help not only in setting goals but also to decide the strategies"				
	3) Reminder notification for the target, task and deadline	Students (Group 4): "I don't know what the name is, but maybe like a learning status. Also, some activities related to performance can be captured as well in a dashboard, for example, we know that turns out we have not done this assignment and information that notifies us that we get feedback for this assignment from the facilitator" Teachers 3: "In addition to my previous idea for centralized information about the tasks, there can be a notification as well to inform the assigned task"			41 (11)	80 (4)
Real-time monitoring	Recording and tracking: 1) The learning activities	Students (Group 5): "After we have completed it, it can be a reflection too, like how far we have completed the work on that day. Hopefully, it will help the person to become more reflective. So, they know their progress each day and accumulate to each week, each chapter, and so on. We can see the tracker, progress, and the report. Similar to the apps that we usually to exercise at the gym. We can see the graph for each week, each day, and month. We can see whether it decreases or increases and if it increases, we can set it to keep on that pace. If it decreases, we can reflect, maybe we need to adjust our learning method or why I am being like this, what the cause is, is it because of my condition during the study, or any other personal problem? So, we can encourage people to do self-reflection" Teachers 2: "Like, how much time they spend learning or reading the	C4	DP1	33 (9)	60 (3)

(*continued*)

Table A4.

Features	Subfeatures	Examples	CN	DP(s)	% Learners	% Teachers
		materials, whether they optimize the Q&A session during class, how much time I do the practice, and what my learning strategies are. To better evaluate ourselves, we need to see all those factors as well"				
	2) The progress of learning goals	Students (Group 9): "To help me execute consistently, I need to have a sense of progress. It can show the percentage of my progress" Teachers 5: "Maybe we can acquire the data based on their goals set previously and we can use it as a reminder for them, like 'this is your goal, keep doing it so you will keep on the right track', or something like that to keep them on the track"			56 (15)	100 (5)
	3) Enable to observe peer's learning activities progress	Students (Group 8): "We also can see whether we have submitted the challenge and who has not. So, it also encourages us to accomplish the task because we see that other people have submitted theirs… Maybe, there will be a time that it will be helpful, but it can also make us procrastinate because we see that other people have not submitted theirs yet" Teachers 2: "The goal is to make them have references on various learning strategies that might help them to be better… Actually, we need to strengthen their self-evaluation so they can stop comparing themselves with others. So, ideally, they can evaluate their own progress. Comparing with others is enough for the beginning only, for example, just to set the ideal examples but after that how to achieve our goal will depend on our own ways. So, we need to strengthen the self-evaluation"			30 (8)	20 (1)
Help-seeking	1) Recommendation and access for connecting to resourceful experts or peers	Students (group 5): "I'm thinking if there is an ongoing discussion outside the class session, which in my case is quite active, we can have some reminders, like 'hey, some people are having a discussion, why don't you join?.' At least, even though they are still working, at least they can check later based on the reminder and get encouragement to join and learn from it"	C5	DP4	78 (21)	80 (4)

(*continued*)

Table A4.

Features	Subfeatures	Examples	CN	DP(s)	% Learners	% Teachers
	2) Function to support psychological safety	Teachers 3: "I'm thinking to have a feature that can connect the students with student centre support. They can connect, like, with our current psychological support. They can connect with the alumni too. In addition, storytelling is still important. Other than that, they can also be connected with other experts, other than the facilitator" Students (Group 1): "I can imagine that during the Bootcamp, there are so many silly questions. So, it might be helpful if there is a forum or some kind of anonymous forum where you have no fear in asking silly questions" Teachers 2: "Based on my experience so far, the most effective way is when I can put myself in their shoes or accept them for whom they are without judging them. What I usually do is stand by their side or validate their feeling first, then we can help to guide them. But, this is very personalized, case-by-case. We need to see their perspectives first then we help them based on their cases. That is the most effective support based on my experience. Validating them and then guiding them. Like, providing them with a safe space. It is also hard since this is in online settings where you have very limited social interaction to help encourage them directly. Even for further cases, for example, when we have to face students with lower education backgrounds or coming from rural areas. We need to re-align their value first, whether we should agree or disagree with their values at the beginning. For example, they have some bad experiences in their area or culture that make them have specific insecurities in the new environment even though they should not be worried about that because it is still accepted, for example, in the metropolitan city's environment. So, these cultural contexts sometimes also need to be addressed first to make them feel more comfortable during their learning process"			48(13)	40(2)
Stimulating interests and excitement during learning	1) Gamification elements	Students (Group 1): "To motivate, maybe I need a sense of completeness. For example, if I have succeeded in completing task A B C, I can get a reward or some points that can be exchanged to some prices, like Binar hoodie. If we complete a quiz, we can get 1 or 2 points. Maybe it will boost motivation. I mean, I personally like when	C6	DP2	48(13)	40(2)

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Table A4.

Features	Subfeatures	Examples	CN	DP(s)	% Learners	% Teachers
		my facilitator appreciates me, and maybe they can sometimes share a Voucher for a free short class in Binar or a free subscription to learn other things in Binar. Maybe, it will motivate me to study more. But, maybe people have different needs"				
	2) Personalized notification for motivational messages	Students (Group 7): "We need the motivation to keep reminding us of why we need to be consistent and to remind us of our goal in the beginning because sometimes it is missing in the middle of the process" Teachers 1: "So, it is more like to inform what this will be beneficial or valuable for future work. It can be in the form of a reminder message, such as 'let's be on time for this because it will be required later in the workplace' or 'let's focus on this topic because it will be beneficial to be used later in your future work.' It likes fun facts but consists of useful messages so it can remind them of the reason why they learn this or what the material is about"			19(5)	80(4)
Strategy to rehearse and construct knowledge	1) Prompt and direct feedback to rehearse information	Students (Group 7): "Just to add, maybe there can also be some additional challenges (tasks), for example, 10 days of challenges to learn HTML which will consist of challenges and theories consisting of various materials, like video. So, people who would like to push themselves in that part, can join that challenge and complete it. If they can complete it, there will a reward as mentioned before" Teachers 5: "Let's say we already have a set of learning goals in each chapter. Then, there would be a live quiz that they can use to rehearse deeper knowledge that can provide feedback directly to show them what they can improve directly"	C7	DP1, DP2 and DP3	52(14)	80(4)
	2) Stimulate self-learning	Students (Group 9): "The story can also remind us to learn the next materials, like "now you have learned 'media planning.' Next time, we will explore Facebook Ad" Teachers 4: "It helps facilitate students' curiosity and self-learning, like 'I'm curious about this topic, I would like to try this topic first by doing some of the practices.' Secondly, it also can help students to recall or rehearse, like 'yesterday, I learned about this. I would like to test my capabilities by doing these exercises.' I think it will help them to be consistent to learn"			56(15)	80(4)
	3) Reminder notification to review and revisit materials	Students (Group 9): "Other than that, a reminder would be great to remind us to study, like refreshing the previous materials. Maybe the			44(12)	40(2)

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Features	Subfeatures	Examples	CN	DP(s)	% Learners	% Teachers
		reminder can be something like 'how was your study about Facebook Ads yesterday, do you feel that you already understand it well?' That's what I'm thinking" Teachers 5: "Other than that, if they have learned about something but they still do not yet meet the standard, the reminder also can encourage them to re-learn about that specific topic"				
Self-reflection phase: self-judgment and self-reaction						
Self-evaluation analytics based on various standards and recommendations for adaptive improvements	Comparison to: 1) Certain targeted output criteria	Students (Group 8): "We know the maximum score and our score. So, yeah, maybe there should be a maximum score, like 100, and if I get 70, then it will be shown 70/100. In addition, the standard should be told in the beginning, how much that we should achieve to be graduated. So, for example, I know to graduate I need 500 points. In the first week's challenge, I only get 70, then I know how and in which part I could collect more points"	C8	DP1 and DP3	59(16)	60(3)
	2) Group performance without competition aspects	Students (Group 3): "Regarding the score that can be seen in the dashboard, I personally okay if I could also see my peers' results. But, some people might not like to show it. So, it can have 2 side effects. It can give you a productive pressure to make you more motivated. Or, make you feel demotivated because you feel like you are not good enough compared to others. Maybe it can be only for certain information. For example, the name rank can be shown in public but not like the exact score because maybe the score gap can trigger demotivation. That's my perspective so far related to score dahsboard" Teachers 1: "In my opinion, it is still natural that we need to learn from our groups. At a certain point of development ages, we also need to learn internally. Some people still rely too much on learning from others only. So, we can still provide that information but with some limits, for example, we can provide the average score from groups, like the max or min but anonymous. It might be something that they want but can be something they don't need"			59(16)	80(4)
	3) Own standards or past performance track record	Students (Group 7): "It is interesting to have the dashboard so we can evaluate ourselves and see the graph to know how much we improve"			48(13)	80(4)
	4) Review from the experts	Students (Group 2): "There was also some descriptive feedback that was quite personal so it can help to not only evaluate myself but also boost my motivation for the future"			63(17)	60(3)
					33(9)	20(1)

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Table A4.

Table A4.

Features	Subfeatures	Examples	CN	DP(s)	% Learners	% Teachers
	5) Review from peers or other references	Students (Group 9): "I feel a need to know the review that I get from my peers and facilitators. For example, now during group work, we get to review our group members, but I couldn't see the result. I agree that it should be anonymous as well. I'm thinking it is a good system to review each other and it is good that we can see the review regarding our performance. Maybe, in every session, we can have a method to review each other. For example, each student can post their challenge (tasks) result or contribute by making some quiz questions and answers. Then, other people can see other people's answers to their questions, learn from them, and review whether it is helpful, relevant, or of good quality. For example, people can rate it as 1 or 5 stars. Hopefully, it can trigger people to perform better in their studies. We can see whether we get a good rating from our own questions and answers and reflect that 'oh people like my opinion'. So, it can trigger more motivation to perform better" Teachers 4: "I feel, yes, it is needed because sometimes the feedback can be not comprehensive enough or there are some people that may have experience outside the study so they might also compare with how it should be in real life. So, the standard can come not only from the facilitator. Maybe, in addition, we can also provide a standard based on a career goal, for example, if you would like to be a Full-Stack Engineer, what do you need to have or what kind of things are required in the hiring process? So, it can be a standard based on real-life practice"				
	6) Recommendation on future improvement and learning goals	Students (Group 4): "A summary of score to show our performance progress, like what things we still need to improve and what we have been good at" Teachers 1: "When they redo the plan, they evaluate all the processes based on the tracking that they have to see what they can improve in the future. So, we can add one more prompt on the worksheet, like 'what can you do differently from the previous chapter for the next chapter?' From this data, we already can evaluate. We have the before	52 (14)	80(4)		

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Features	Subfeatures	Examples	CN	DP(s)	% Learners	% Teachers
		and after data. What they adjust and the reason. It will help them to check their learning process"				
Ethics and data preferences						
Trustworthy information	1) Data privacy	Students (Group 10): "Maybe age is still okay because maybe it is important for applying for a job after the Bootcamp, for example. So, something that is not too personal, like age and name. But, if it will be shown to the public, I rather not have my full name, score, and learning result to be shared to the public. It is still okay if it is for personal consumption" Teacher 1: "I think the one that is not ethical is when we force them to share all the detailed information, like their detailed daily activities. They can just provide general information about their activities or just like in the calendar; we can see that people are busy at that hour without they have to show detailed information regarding their activities"	C9	DP5	81(22)	100(5)
	2) Data transparency	Students (Group 5): "Personally, as long as, we were asked for consent in the beginning on what kind of data and for what purpose, I think I'm okay if it is for the purpose of the learning analytics" Teachers 3: "The purpose needs to be clear"			63(17)	60(3)
	3) Data security	Students (Group 2): "In general, I don't have any concerns. However, the issue might be more on how to be sure that the server will be saved, and that the data will not leak or be utilized for the wrong purpose. So, my concerns are more on making sure the data is saved and is used only for the purpose of learning analytics and not for other purposes"			19(5)	0(0)

Source: By authors

Table A4.

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