MoTE: Development of a Tool for Monitoring of sTudent Engagement

Jorge Maldonado-Mahauad[1], Felipe Mendieta[1], Carlos Muñoz[1], Carlos Alario-Hoyos[2]
[1] Department of Computer Science, University of Cuenca, Cuenca, Ecuador
[2] Department of Telematic Engineering, Universidad Carlos III of Madrid, Leganes, Spain
{jorge.maldonado, felipe.mendieta, carlos.munoz}@ucuenca.edu.ec, calario@it.uc3m.es

***Abstract*—Student engagement in learning is crucial for academic performance, motivation, and active participation. However, measuring and responding to student engagement, both in face-to-face and online sessions, remains a challenge for educators. Existing methods, such as self-reports, interviews, and even real time eye-tracking tools lack a multidimensional engagement approach (that is cognitive, affective, and behavioral). In response, this article presents the development and evaluation of MoTE, a real-time tool for monitoring student engagement. Following a Design-Based Research methodology and Interactive Learning Design framework, we detail the phases of identifying indicators and visualizations to meet the needs of teachers and students, culminating in the implementation and evaluation of an initial prototype. A local evaluation with 146 students and a broad evaluation with 58 students provide valuable insights into the indicators, dashboards, and functionalities to designing effective student engagement tracking tool. This work not only proposes an innovative approach to assessing engagement, but also opens avenues for future research and practical applications in education.**

Keywords — Engagement, Learning Analytics, Feedback, Class Interaction.

I. INTRODUCTION

The incorporation of digital technology in higher education has profoundly transformed the student experience, modifying traditional teaching and learning structures. This change points to the need to adopt new pedagogical strategies that complement technology with teaching methods to improve the educational process [19]. However, the mere presence of technology in the classroom does not in itself guarantee a significant educational advance [26]. It is therefore necessary for their integration to facilitate teachers' approach to students in a more meaningful way, promoting a learning environment that stimulates students' affective and cognitive commitment to their educational process [6]. In this context, a central concern among teachers emerges and is the decrease in student engagement in the classroom, whether face-to-face (i.e., face-to-face) or remotely (i.e., online) [12]. Student engagement plays a crucial role in the teaching and learning process of students. According to recent research [1], the level of engagement is a key indicator of academic performance, cognitive development, and is even a predictor of student dropout. A high degree of engagement means that students are emotionally and cognitively involved in their learning [1]. This translates into increased motivation, active participation in the classroom, and better academic performance.

The role of the teacher is fundamental in promoting this engagement [1], where the effective integration of digital technologies in the classroom can serve as a valuable tool to capture data on student engagement, offering teachers the opportunity to design or redesign their pedagogical practices based on data evidence [26]. In this way, more effective strategies adapted to the needs of students can be promoted.

For contributing to the field of study, this paper presents MoTE (Monitoring sTudent Engagement), a real-time tool for monitoring student engagement, designed to overcome the limitations of existing tools and provide a tool that encompasses the needs of both teachers and students. MoTE addresses the need to monitor and encourage student engagement, highlighting its importance for academic success.

To achieve this, this paper explores various definitions and models of student engagement that highlight its complexity and the variety of factors that influence it, from active involvement in learning to emotional well-being and behavioral participation in the educational environment. In addition, this paper examines existing computer techniques and tools designed to assess and monitor student engagement, which have served as technological innovations that have shaped the way educators and researchers approach student engagement.

This paper is organized as follows. Section 2 presents the related work and research questions; section 3 describes the methodology used and how the tool was designed and implemented. Finally, section 4 presents a summary of the main results and future work.

II. RELATED WORK

A. Definition of Student Engagement

Several researchers have offered various definitions of student engagement. For example, authors such as [10] mention that engagement usually refers to the level of involvement and effort of students in learning. [30] describes student engagement as the participation of students in teaching activities, while [4] proposes the definition of student engagement in the context of a university class as a result that is experienced continuously and arises from the dynamic interaction between motivation and active learning. For the purposes of this article, student engagement is defined as the level of energy and effort that students devote to their learning environment [6]. The definition of student engagement is broad and encompasses cognitive, emotional, and behavioral aspects, with a focus on student attention, participation, and motivation.

The cognitive dimension of engagement refers to mental processes and activities related to learning and understanding. This description involves students' active participation in meaning-making, critical reasoning, and problem-solving. A cognitively engaged student shows a high level of attention and concentration on academic tasks, as well as a desire to acquire new knowledge and skills [6]. The emotional dimension of engagement focuses on students' emotional and affective responses to the educational environment (teachers, classmates, studies, and school). It involves feelings of emotional connection, satisfaction, well-being in relation to learning and the academic experience. Affectively engaged students show enthusiasm, interest, and a positive attitude toward the learning process. The behavioral dimension of engagement refers to the observable actions and behaviors of students in the educational context. It involves active participation in learning activities, interaction with peers and teachers, and regular attendance at classes. Behaviorally engaged students show a high level of participation and dedication in their educational process

B. Student Engagement Models

Student engagement arises with the aim of improving student learning and understanding how it relates to school dropout and successful completion of their studies [22]. Nowadays engagement has a multidimensional vision that adds different approaches such as emotion, behavior, cognition, among others. The following models provide diverse frameworks for understanding how and why students engage in their teaching and learning process. The participation model based on [29] presents a formal definition of student engagement and disengagement highlighting that student engagement occurs when they actively participate in the activities proposed by the school program. This view presents engagement and disengagement as opposing concepts and points out that the absence of commitment manifests itself through absenteeism, apathy, and demotivation among students. The participation and identification model introduced by [9], according to [5], distinguishes between the behavioral (participation) and emotional (identification) components of student engagement. Participation is defined as the active involvement of the student in both academic and non-academic activities, considering absenteeism as a negative form of participation. Identification refers to students' sense of belonging to their school, where they feel accepted, supported, and value education.

Flow Theory, proposed by [17], focuses on the optimal human experience known as "flow", a state of mind of total immersion and concentration on an activity. This theory suggests that flow is reached when there is a balance between the person's skill level and the challenge presented by the task. Learning is most effective when students are in a state of flow, as this favors the retention of information, the solution of complex problems, and the enjoyment of the learning process, thanks to clear objectives and immediate feedback.

The Multidimensional Model proposed by [10] defines student engagement as a meta-construct that includes three main components: cognitive, affective, and behavioral. This model transcends the idea of simple participation, emphasizing not only the importance of active or behavioral involvement of students, but also the relevance of the emotional and cognitive aspects of engagement. For this work, this model has been taken as a reference, since its multidimensional approach allows a more complete understanding of engagement, facilitating the identification of more effective pedagogical and intervention strategies to promote all aspects of student engagement. In addition, it provides a robust framework for investigating how different components interact with each other and contribute to academic success by considering engagement from these three interrelated dimensions

C. Techniques and Tools for Monitoring Student Engagement

Monitoring student engagement is challenging due to the diversity of its components, but various tools and techniques have been developed to account for engagement. Among the most common techniques are: (1) Self-reports, which collect data directly from students about their own learning experience, although they vary in content making it difficult to compare between studies [8]; (2) Interviews, which provide an in-depth understanding of the reasons for the variability in student engagement, offering details about their experiences and influencing factors [11]; (3) Observations, useful for identifying individual or group engagement-related behaviors, both positive and negative, by assessing academic behavior [24]; and (4) Real-Time Measures, such as log files and eye tracking, which provide data on fluctuations in student engagement in online activities, although they present challenges in interpreting the data for pedagogical application. These techniques demonstrate the complexity of measuring student engagement and the importance of selecting appropriate methods to improve education [24].

In relation to the tools used to analyze student engagement, they have undergone a revolution thanks to the development of computer tools that allow an accurate and real-time evaluation. These computer tools include: Classmoto, a web application designed for university environments, which stands out for its ability to measure the social, affective, and cognitive dimensions of engagement. Through short questionnaires administered during class, teachers can obtain instant feedback, visualizable on a dashboard that reflects both the overall and individual level of student engagement, as documented by [7] SEAT, introduces a multimodal methodology to assess engagement, collecting data through cameras, audio, and web browsing. This application processes the information collected to offer teachers a dashboard that facilitates personalized intervention at critical moments of student disengagement, as highlighted by [2]. Another tool is Sens, that emerges as a solution to analyze behavioral and affective engagement in real time, using cameras and environmental sensors to capture students' degree of attention and emotional responses. The data obtained allows educators to optimize teaching strategies and improve the educational experience, as detailed in [28].

Finally, Real Time Camera proposes a novel approach based on facial and pose recognition to monitor students' attention in the classroom, using machine learning algorithms to assess engagement [27]. These tools have significantly improved the understanding and monitoring of engagement, contributing to the evolution of pedagogical methods in digital educational

environments. Table I presents a summary of the previous tools presented.

TABLE I. SUMMARY WITH IT TOOLS TO MEASURE ENGAGEMENT

Tool	*Methodology*	*Technologies Used*	*Main results*
Classmoto	Web application to measure student engagement in the university environment.	In-class quizzes, social, affective, and cognitive engagement.	Effectiveness in collecting data in real time, immediate visibility for teachers, limitations identified with recommendations for future development.
SEAT	Multimodal technology Real-time student engagement analytics.	Built-in camera, platform data, URL, video, and audio logs.	Significant impact on teacher practices, less boredom in students, real-time personalized support.
Sens	Solution for real-time behavioral and affective data collection.	Environmental sensors, Camera for attention metrics, dashboard.	Real-time data collection, strategic decision-making for teachers, improved learning experience.
Real Time Camera	Camera monitoring for Facial Recognition and Head Poses in real time.	Facial recognition, head poses, distraction scoring.	Success in Facial Recognition and Head Poses, Associating Distraction with Student Attention.

Each of the tools presented in the Table I to measure student engagement in educational environments has its own limitations. Classmoto, although effective in collecting real-time data and providing immediate visibility for teachers, faces restrictions that have been identified and require recommendations for future development. SEAT, which uses multimodal technology for real-time student engagement analysis, has a significant impact on teaching practices and reduces student boredom, but its reliance on multiple data sources (camera, platform, URL, video, and audio logs) can complicate its implementation and continuous use. Sens, which collects real-time behavioral and affective data through environmental sensors and cameras for attention metrics, offers real-time data collection and strategic decision-making for teachers, but its focus on sensors and cameras may present challenges in terms of privacy and acceptance by students. The Real Time Camera tool, specialized in monitoring facial recognition and head poses in real-time, has been successful in these specific areas and in associating distraction with student attention; however, its application may be limited to contexts where these metrics are prioritized. Finally, while these tools have proven to be effective and useful in measuring student engagement, the wide variety of questionnaires, visual, auditory, and tactile analyses, along with the use of cameras and sensors, can present challenges in integrating and managing this diverse data in different educational contexts. Additionally, many of these methods are invasive for students, necessitating a less intrusive tool that students are more familiar with and comfortable using. Another important factor from the perspective of educational institutions is that most of the tools presented in Table I for measuring engagement are expensive to implement and not freely accessible. For these reasons, MoTE has been designed as an open mobile tool (https://mote.ucuenca.edu.ec/).

D. Contribution and Research Questions

This paper presents the design process followed for developing MoTE (Monitoring sTudent Engagement), a real time tool for monitoring student engagement. The goals of the MoTE tool are: (1) to monitor student engagement; (2) to provide a dashboard with data visualization for the teacher; (3) to facilitate interaction between students and faculty; and (4) to ensure usability and accessibility. To this end, MoTE collects data on student engagement in the educational context (face-to-face / online). Two research questions guided the whole design process for implementing MoTE that are described in this paper:

- **(RQ1) What are the indicators and visualizations that should be included in a tool for monitoring student engagement?** To identify what visualizations and indicators in prior work could serve as a basis for proposing an interactive tool.
- **(RQ2) How end-users perceive a prototype of a tool including the identified indicators in terms of usability and user experience?** To evaluate the meaningfulness of the dashboards produced for both teachers and students

III. METHODOLOGY

For the design of MoTE we followed the Design Based Research (DBR) methodological approach [21]. This approach mixes empirical research on education with theories oriented towards the design of learning environments, from the analysis and design to the implementation and evaluation. To apply the DBR methodological approach, we used the Interactive Learning Design (ILD) framework [3]. The ILD framework organizes the research process into four phases: (1) Informed exploration, in which we studied the needs, available theories and audience of the tool; (2) Enactment, phase in which the design of a tool is proposed and implemented; (3) Evaluation of local impact, which aims at evaluating the impact of the intervention at a local level, focusing on particular research questions for that context; and (4) Evaluation of broader impact, which considers the analysis of the technological intervention into a wider audience (see Fig. 1). Each of the phases is described below.

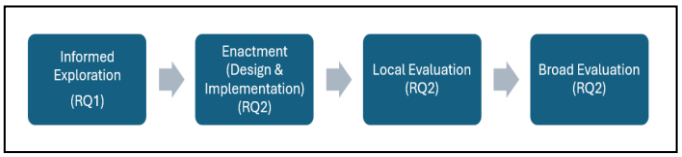

Fig. 1. Cycles of the ILD framework conducted for developing and evaluating MoTE.

A. Informed Exploration Phase

The main objective of the Informed Exploration phase was to identify indicators of engagement to be included in MoTE tool considering both teachers and students (related with RQ1). Specifically, we conducted an analysis of existing indicators

used in existing tools to identify the indicators to be used in MoTE tool. This process was structured into two steps: (1) analysis of existing indicators; and (2) selection of indicators.

Step 1. Analysis of Existing Indicators. We conducted an analysis of the indicators from a multidimensional perspective of student engagement. Within the literature, it is possible to evidence different indicators that have been used [22], and vary in the number of items for each component and according to the sources consulted. Finally, based on a recent systematic review of [6], a ranking of the five most used indicators is presented (see Table II).

TABLE II. MOST USED STUDENT ENGAGEMENT INDICATORS

N.	*Behavioral*	*Affective*	*Cognitive*
1	Participation/Interaction/Involvement	Positive interactions with classmates/teachers	Learning from peers
2	Achievements	Enjoyment	Self-regulation
3	Confidence	Interest	Deep Learning
4	Taking Responsibility	Enthusiasm	Critical Thinking
5	Study Habits	Feeling of Connection/Satisfaction/Excitement	Focus on the task at hand

The most used student engagement indicators encompass behavioral, affective, and cognitive dimensions. Behavioral indicators such as participation, achievements, confidence, responsibility, and study habits reflect students' active involvement and commitment. Affective indicators, including positive interactions, enjoyment, interest, enthusiasm, and feelings of connection, highlight the emotional aspects of engagement. Cognitive indicators like learning from peers, self-regulation, deep learning, critical thinking, and task focus demonstrate the intellectual engagement of students. These indicators provide a comprehensive understanding of how students interact with, feel about, and cognitively process their educational experiences.

Step 2. Selection of Indicators. Based on the list of indicators in Table II and considering the four objectives of MoTE (section 2.4), several indicators were selected to monitor and reflect the multidimensions of student engagement (behavioral, cognitive, and affective – see Table III). MoTE can complement the other reviewed tools by providing a more integrated and less intrusive approach to measuring student engagement. While tools like Classmoto, SEAT, Sens, and Real Time Camera offer valuable insights through various data collection methods, MoTE aims to streamline these insights into a mobile platform that is accessible and user-friendly for both students and educators. The decision to include specific indicators in MoTE was based on their proven effectiveness in capturing critical aspects of engagement. Behavioral indicators such as class participation reflect active involvement, cognitive indicators like self-regulation towards goals encompass deep learning processes, and affective indicators such as belonging and emotional state capture the students' connection and feelings towards their educational experience. By integrating these selected indicators, MoTE provides a comprehensive yet streamlined method for tracking and enhancing student engagement in diverse educational settings.

TABLE III. INDICATORS SELECTED ENGAGEMENT INDICATORS

Component	*Indicator*	*Variables*
Behavioral	Class Participation	Comments and doubts in class
Cognitive	Self-regulation towards goals, metacognition, deep learning	Answering surveys, understanding, or not understanding a topic
Affective	Belonging, perceived connection at school with teachers and classmates, interest, pleasure.	The student's emotional state throughout the class

The indicators and variables presented in Table III provide a structured framework for designing MoTE, focusing on the behavioral, cognitive, and affective dimensions of student engagement. For the behavioral component, the indicator of class participation, measured through comments and doubts in class, can be incorporated into MoTE by including action buttons for students to submit questions and comments in real-time. This will allow for active monitoring and encourage student involvement.

In the cognitive dimension, indicators such as self-regulation towards goals, metacognition, and deep learning can be assessed through options for students to answer surveys, provide feedback on their understanding, or indicate if they do not understand a topic. Action buttons for these responses can facilitate real-time adjustments in teaching methods and materials to better suit student needs. For the affective component, indicators like belonging, perceived connection with school, interest, and pleasure can be tracked by monitoring the student's emotional state throughout the class. MoTE can include features such as mood trackers or prompts for students to express their feelings about the class. These could be implemented as simple action buttons or sliders that allow students to indicate their emotional state at various points during the lesson. By integrating these indicators and variables, MoTE can offer a comprehensive and dynamic tool for educators to measure and enhance student engagement. The use of actionable buttons and interactive features ensures that data collection is seamless and that student feedback is continuously incorporated into the learning process

B. Design and Implementation

This section is to detail the design and implementation process of MoTE, from initial conception to final iteration. It presents how the tool was designed and how the functional and non-functional requirements were discovered, ensuring that it suits both the users and the educational purpose. The design and implementation are also inspired by the Lean Startup methodology of [23], which advocates agile and adaptive product development, and the principles of usability and user-centered design, as described [18]. MoTE seeks not only to be a tool to collect data on student engagement, but also a means to improve educational dynamics through effective communication and real-time feedback. This iterative, evidence-based approach is essential in the field of educational technology development, enabling the creation of solutions that are not only

technically feasible, but also pedagogically valuable. The structure of MoTE is divided into two core modules: the student's and teacher's interface.

1) ***Student Interface***

The first prototype screens were designed using the Design by Analogy (DbA) method [13]. This practice involves adopting successful design features from established applications. Based on the theoretical foundations, initial functionalities such as surveys and real-time comments were proposed. Applying DbA, Kahoot features were used for login and Socrative Student for student surveys. The first prototype is shown in Fig. 2.

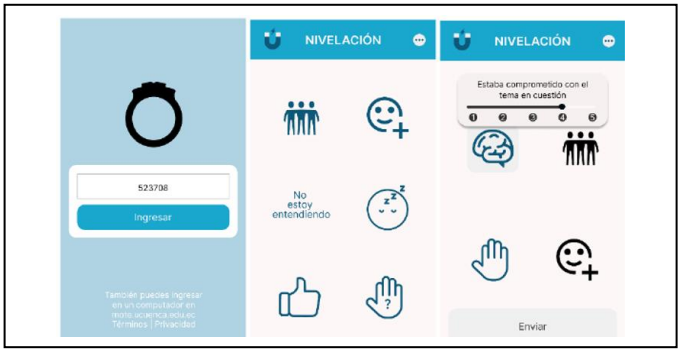

Fig. 2. First iteration of MoTE.

Once the first interactive prototype of MoTE (see Fig 2.) was completed (based on literature review and Table III), early feedback was received from the 3 researchers who were experts in the field of educational technologies through interviews. Through these interviews, it was possible to initially validate the iconographic options used to reflect the multidimensionality of student engagement in the MoTE tool. In addition, 15 students and 10 teachers were also interviewed about their perception of the first screens. Based on the results of the interviews, new features were added, and some screens were restructured (thus aligning with DBR). To improve the aesthetics and accessibility

Fig. 3. Second prototype of MoTE tool

of the interface, the universal design principles of [15]. Fig. 3 presents the result of the second iteration of MoTE. New features were added, and some screens were restructured.

2) ***Teacher Interface***

We started with a rudimentary prototype exploring ideas and possible functionalities applying the same methodology as the student, in this way key functionalities were discovered, and the appearance was redesigned, functionalities were modified. Design by Analogy was used in the menu, inspired by Socrative for Teachers. Inspiration from Socrative, can be designed to provide real-time insights and facilitate interactive engagement. Similar to how Socrative allows teachers to create quizzes, monitor student responses instantly, and adjust teaching strategies based on immediate feedback, the dashboard can include features that track student participation, comprehension, and emotional engagement during lessons. For instance, the dashboard could offer real-time data visualization tools that display student engagement metrics, such as participation rates, question response times, and emotional feedback captured through quick polls or mood indicators. By providing these interactive and real-time features, the dashboard can empower teachers to make informed decisions, improve student engagement, and enhance the overall learning experience After several interactions and based on feedback from 3 educational experts, the teacher's dashboard was aligned with the teachers' needs (see Fig. 4).

Fig. 4. Dashboard Prototype of MoTE for teachers.

3) ***Description of the tool***

The interaction design process highlights the growing popularity of emojis as a means of communication in digital environments. It has been recognized for its ability to clarify communicative intentions, play verbal and nonverbal roles in communication, and reveal aspects of the user's personality [14]. In this context, emojis were used to design interactions, capturing them through taps that will then be visible to teachers through a dashboard.

Behavioral Engagement: One of the procedures that teachers can follow to best engage students is through class discussions or activities in which anonymous responses are used. Using the traditional method of raising your hand can cause some students to be reluctant to answer a question posed in class and only get to participate when other classmates respond, [20]. Taking this into account, two options were created to monitor this indicator, sending comments, and sending doubts to the teacher. The options are represented by two buttons (class comment and question mark).

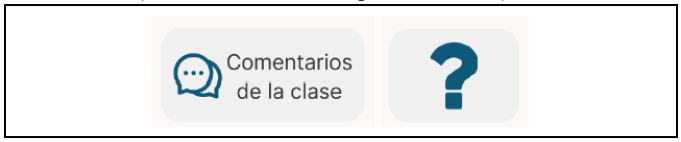

Fig. 5. Buttons for behavioral engagement in MoTE.

Cognitive Engagement: Gaining insight into the cognitive component of student engagement is challenging because it is not as easily observable as behavior. However, one way to address this challenge is to employ electronic devices to provide feedback, in combination with questions aimed at extrapolating students' levels of cognitive, behavioral, and emotional engagement. The options are represented by two buttons (survey, I don't understand).

Fig. 6. Buttons for cognitive engagement in MoTE.

Affective Engagement: To monitor this indicator, three options will be created, which will allow you to monitor the following indicators (Excellent class, I'm sleepy, request a break, express my emotions):

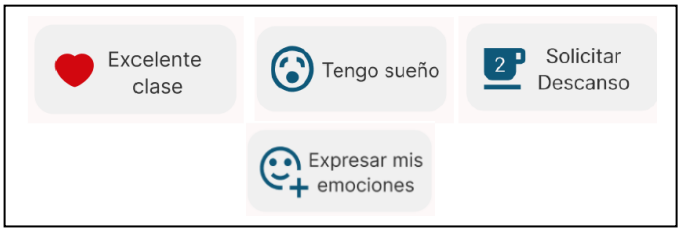

Fig. 7. Buttons for affective engagement in MoTE.

C. Local evaluation

Local evaluation was conducted to understand **How a prototype of a tool including the identified indicators is perceived by the end-users in terms of usability and user experience (related with RQ2).** For the local evaluation**,** 2 face-to-face classrooms and 1 online classroom were selected to carry out the tests, with a total of 146 students actively participating (G1 face-to-face n= 23, G2 face-to-face n= 25, G3 online n= 98). The selection of these groups was carried out with the aim of covering different learning contexts. Participants were invited to participate voluntarily. Usability and user experience testing took place between November 3-2023, and January 9-2024. To comprehensively evaluate the usability and user experience of the MoTE application, two recognized evaluation techniques in the field of human-computer interaction were used: the System Usability Scale (SUS) questionnaire and the User Experience Questionnaire (UEQ). In addition to the SUS and UEQ questionnaires, qualitative feedback was collected from students through open surveys and group feedback sessions.

Results of the local evaluation: In relation to the UEQ, values > 0.8 represent a positive assessment and values < -0.8 represent a negative assessment [25]. Table IV presents the summary of the results. UEQ data reveal variations in user experience perceptions among participating groups, with the online G3 group reporting higher scores in nearly every category assessed. This suggests that MoTE could be perceived as more useful and effective in virtual learning environments, possibly due to a greater reliance on digital tools for interaction and engagement in these environments. These differences could also reflect the nature of interactions in face-to-face or virtual environments, where nonverbal communication and group dynamics in physical classrooms can influence the perception of the need and usefulness of the tool.

TABLE IV. UEQ RESULTS SUMMARY

Components	*Mean G1 (sd)*	*Mean G2 (sd)*	*Mean G3 (sd)*
Attraction	1.4 (1.4)	1.6 (1.1)	1.5 (0.9)
Transparency	0.9 (1.5)	1.5 (1.2)	1.6 (0.7)
Efficiency	1.2 (1.1)	1.4 (1.3)	1.8 (0.8)
Controllability	0.8 (1.4)	1.0 (0.8)	1.8 (1.0)
Stimulation	1.0 (1.5)	1.0 (1.6)	2.0 (1.3)
Novelty	1.2 (0.8)	1.0 (1.2)	2.5 (0.7)

In relation to SUS, a single value is produced that reflects an overall measure of the usability of the system. The contribution of each item of the questionnaire has five options ranging from 0 to 4 (ranging from Strongly Agree to Strongly Disagree). SUS scores range from 0 to 100. Table V presents the summary of the results. The results of SUS indicate a variability in the perception of the usability of the tool among the students of the different groups. While some students highly valued the usability of the application, others expressed difficulties, suggesting areas for improvement in the interface and user experience. The variability in these scores underscores the importance of considering a wide range of user experiences in the tool design and continuous improvement process

TABLE V. SUS RESULTS SUMMARY

Components	*Mean by group*	*SUS Score*
Group 1 – Face-to-face	74.8	Good
Group 2 – Face-to-face	69.75	Good
Group 3 – Online	84.25	Excellent

Qualitative feedback: The qualitative analysis of the feedback provided by the students revealed several key aspects to improve both the interface and the functionalities of the tool. Notable suggestions include: (1) the addition of new emotions to register more specific states such as "tired" or "bored", (2) the need to improve the organization of the interface and the inclusion of functionalities such as a timer for the class, (3) some students also expressed the need to make the tool more visually appealing, (4) suggestions to ensure that the progress of the tool bar is not lost when the page reloads, and (5) the need for the tool to automatically sense a response from the student every 35 to 40 minutes. This allows us to know that students want to communicate their needs to the teacher in each of the class sessions.

D. Broad evaluation

As a broad evaluation a pilot study was conducted **to understand how students perceived the prototype MoTE in**

terms of interactions with the tool (related with RQ2). For the broad evaluation**,** 2 face-to-face classrooms and 1 online classroom were again selected to carry out the tests, with a total of 58 students actively participating (G1 face-to-face n= 13, G2 face-to-face n= 25, G3 online n= 20). This analysis is not intended to be exhaustive, but rather seeks to lay the groundwork for future iterations of MoTe**.** From the interactions, it is possible to identify the functionalities most used by students and those that require a redesign in MoTE. This is done to align with the educational and emotional needs of the students. Data collection was done by automatically recording the use of the options in the tool within a MongoDB database. This method made it possible to capture accurate and detailed data about each student interaction with the tool, including the date, time, and nature of each action. The tool's logs provided a rich source of real-time data, reflecting how students interact with the different functionalities offered. For the analysis of the interactions, it was identified that students could activate the same option several times in a short period of time (for example, selecting "I am sleepy" 10 times in a few seconds). To avoid overestimating these repetitive interactions and to obtain a more accurate reflection of student participation, it was decided to analyze the frequencies per minute of the students. That is, in the span of one minute, the non-repeated interactions of the same student were counted, thus allowing a more accurate assessment of engagement with the application. This approach ensures that the analysis more accurately reflects meaningful interactions and avoids distortion of data due to repetitive multiple entries. Specific interactions evaluated included the options of "excellent class", "I'm sleepy", "I don't understand", "request a break" and "feedback about the class". These options were selected for their relevance to capturing different aspects of student engagement and feedback on the educational experience. Each of these interactions provided valuable insights into students' preferences, needs, and behaviors in the classroom.

Results of the broad evaluation*:* A descriptive analysis of the data was performed to determine the frequency of each type of interaction. Table VI provides a detailed overview of how students use the different functionalities of MoTe in three distinct classes, reflecting the frequency of use and the percentage corresponding to each feature. From this data, it is possible to infer usage preferences and detect areas of potential improvement for the tool interface explained below: **(1) Express my emotions:** this function is the most used, which indicates a high value on the part of students to communicate their emotional state anonymously. Its high frequency of use suggests that the tool satisfies an important need for self-expression in the classroom; **(2) Excellent class**: the second most popular feature allows students to express their satisfaction with the class, which is a positive indicator of engagement. The variation in its use between classes suggests that it may be influenced by the content or dynamics of the specific class; **(3) I'm sleepy, I don't understand, Comments about the class, Request a break:** these features are used less frequently, which could indicate a number of things, such as a perceived lower perceived need for these options, possible psychological barriers to expressing vulnerability or fatigue, a lack of visibility in the tool's interface, or perhaps fear of the teacher. This finding underscores the need for further research into how the interface and user experience can be optimized to foster more open and honest communication about students' needs and difficulties during class.

TABLE VI. SUMMARY OF RESULTS

Function of the application	***Freq. G1***	***Freq. G2***	***Freq. G2***	***Total Freq.***	***% of use***
Expressing My Emotions	22	43	17	82	40.20
Excellent class	2	24	21	47	23.04
I'm sleepy	15	13	2	30	14.71
I don't understand	3	14	1	18	8.82
Comments about the class	3	6	5	14	6.86
Request a break	4	7	2	13	6.37
Total Interactions	49	107	48	204	

IV. SUMMARY OF RESULTS AND FUTURE WORK

In this paper, the Design Based Research process was followed for creating MoTE, a real time tool for monitoring student engagement. From the whole process, we addressed two research questions, which results could serve as an inspiration for those researchers willing to propose solutions for measuring engagement inside the classroom (either face to face or online settings). Regarding RQ1 about the type of indicators and visualizations to be used, we identified through different workshops with experts and teachers: (1) the types of indicators needed for measuring cognitive, affective, and behavioral engagement; and (2) a set of visualizations for representing them. Based on these indicators and visualizations, we implemented a first prototype of MoTE tool to be evaluated in actual contexts. Regarding the RQ2 about the usability and user experience of the end users about the tool. We run a local evaluation with 146 students and a broad evaluation with 58 students. Results indicate that students valued positively the information provided with the tool as good and clear to monitor students' engagement with the session. However, some improvements should be done to improve the tool from both the student perspective. Variability in SUS scores and student feedback highlight specific areas for improvement, such as the need for a more intuitive interface and the inclusion of additional functionality that more accurately reflects students' needs and emotions.

Analyzing student interactions with MoTE reveals important insights into how its functionalities are used in real-world educational contexts. By focusing on improving the interface and relocating or highlighting certain functionalities, a more balanced and effective use of the tool could be encouraged. Based on the findings of this study, the following recommendations are offered for future iterations of MoTE: **(1) Continuous Improvement of the Interface and Functionalities**: It is recommended to continue refining the user interface of MoTE to make it more intuitive and user-

friendly. In addition, it is essential to incorporate new emotions and testing functionalities, such as a timer for class sessions, based on student feedback; **(2) Continuous Evaluation**: it is important to maintain a process of continuous evaluation of usability and user experience, using both quantitative (such as SUS and UEQ) and qualitative (open feedback from students) methods to guide the improvements of the application**; (3) Future research:** the long-term impact of the use of MoTE on student engagement and performance, as well as its effectiveness in various educational settings (i.e., hybrids) and different academic disciplines, should be explored**; (4) Improve the Visibility of Lesser-Used Features:** Considering that lesser-used features can be crucial for students' well-being and effective learning, it is advisable to make them more visible in the interface. For example, placing "I'm sleepy" and "I don't understand" in more prominent places might encourage their use; (**5) Interface Customization:** Allowing students to customize the interface to highlight the functionalities they consider most important could improve the user experience and encourage the use of all available features; **(6) Education and Encouragement of Use:** Through orientation sessions or help materials integrated into the tool, students can be educated about the importance and purpose of each functionality, especially those less used, to encourage more equitable use.

This study also has some limitations that will be addressed in future work. On the one hand, in the Design Phases of the methodology, we have worked mainly with students who were only included for the broad evaluation. Future work will include focus groups and sessions to better design the teacher's side. On the other hand, we conducted the extensive evaluation with only two face-to-face courses and an online course to analyze the user experience and usability issues of the tool. To complement this study, we plan to conduct large-scale, long-term studies to analyze how students and teachers use the tool in the real-world context of learning and its impact on their strategies.

We believe that the results obtained in this work could benefit other researchers in the community. First, we hope that the indicators and visualizations drawn from our empirical study can serve as inspiration for designing new tools for similar purposes. Secondly, we think that the instruments and methods used could also be used by other researchers to validate their own solutions and carry out comparative studies. Finally, we hope that the process described can serve as an example of how to apply the DBR approach to adapt an existing tool to another context.

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