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Development of an Emotion Detection-Based Learning System for Engineering Students at Makassar State University

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Abstract

This study aims to develop an emotion detection-based learning system for engineering students at Makassar State University. The goal is to create a learning environment that is responsive to students' emotional needs, thereby increasing their engagement and academic achievement. The system is designed to monitor students' emotional states in real time, allowing educators to dynamically adjust their teaching methods. The research methodology was carried out through several systematic phases, namely the planning phase (problem identification), design phase, development phase, stabilization phase (testing), implementation phase, and evaluation phase. The study involved 36 students from the Electronic Engineering Education study program as samples. The evaluation method used the System Usability Scale (SUS) with a questionnaire consisting of 10 items to assess the system's usability and acceptability. The results showed that this emotion-detection-based learning system had a good level of usability, with an average SUS score of 78.33. The majority of students found the system easy to use, efficient, and enjoyable. This system has also been proven effective in increasing student engagement during the learning process, as well as providing real-time feedback that helps educators adjust their teaching methods. The emotion detection-based learning system developed in this study has succeeded in creating a learning environment that is more responsive and adaptive to the emotional needs of students. With a high usability score, this system is well-received by users and has the potential to improve learning effectiveness. This research makes a significant contribution to the development of more inclusive and holistic education by combining technology and student-centered pedagogical approaches.

Keywords: Emotion detection; Adaptive learning; Facial expressions; Students; System Usability Scale (SUS)

1. Introduction

Technological developments in education have dramatically changed the way of learning and teaching, making it more flexible and adaptive through the integration of software, educational applications, and Learning Management Systems (LMS) that expand access to learning resources and teaching materials [1] [2] [3]. Technologies such as e-learning and interactive learning platforms allow students to learn anytime and anywhere, while tools such as video conferencing and social media enhance lecturer-student interaction, creating more dynamic communication [4] [5]. The application of big data and analytics in education allows institutions to monitor students' academic progress and understand individual learning needs, making the learning environment responsive to students' needs, including in managing emotions [6] [7]. In addition, innovations such as artificial intelligence, augmented reality, and virtual reality enrich immersive and personalized learning experiences [7] [8]. However, challenges such as the digital divide and the need for technological literacy must still be overcome so that the benefits of technology can be felt evenly [8].

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The importance of learning that is responsive to student needs cannot be ignored because each student has a unique background, learning style, and emotional needs, so teachers need to understand the individual characteristics of students to create effective learning strategies [9] [10]. Responsive learning allows lecturers to adjust teaching methods according to student conditions and preferences, such as through individual learning adaptation and tempo adjustment, which have been proven to increase engagement and motivation to learn [11] [12]. When students feel cared for and understood, their motivation and participation in the learning process increase, which has a positive impact on academic achievement and emotional well-being [13] [14]. The integration of responsive elements, such as the use of adaptive technology, interactive learning, and emotional support, can create an inclusive and supportive learning environment, especially when students are experiencing stress or anxiety [15] [16]. This responsive approach can be implemented by providing additional resources, varied learning methods, and building empathetic relationships between lecturers and students [17] [18].

Emotional intelligence (EI) is a fundamental aspect that supports the transformation of the teaching and learning process dynamics in higher education because EI includes the ability to recognize, understand, manage, and respond to emotions constructively, both in oneself and others [19] [20]. Students with high EI levels demonstrate better adaptation to learning challenges, are able to control stress, and have strong intrinsic motivation to achieve academic goals [21] [22]. Meanwhile, instructors with high EI can create an inclusive and responsive learning ecosystem, are able to read students' emotional signals, and design appropriate pedagogical interventions to support student well-being and achievement [23] [24]. For example, when students experience boredom or academic pressure, instructors with high EI can modify teaching methods or design more interactive activities to reduce this pressure [25] [26].

The social dimension of emotional intelligence (EI) is particularly significant in the teaching and learning process, as the ability to empathize and build positive relationships creates a conducive learning environment that supports collaboration and effective conflict resolution [27] [28]. Students with high emotional intelligence tend to be more skilled in social interaction, collaboration, and conflict management, thereby strengthening interpersonal skills that are important for academic and social success [29] [30]. The implementation of EI in education encourages a holistic approach that not only transfers knowledge but also builds character, empathy, and adaptation skills relevant to the needs of the professional world [31] [32]. Education systems that integrate EI have been shown to produce graduates who are not only intellectually intelligent but also emotionally mature and ready to face challenges in the workplace and social life [33] [34].

Finally, research shows that emotional intelligence contributes significantly to academic and professional success. Students with high EI are better able to persevere in the face of adversity, have effective coping strategies, and are able to turn challenges into opportunities for growth. Therefore, the development of emotional intelligence in education is not just an option, but an urgent need in designing a responsive and transformative education system that can support students in reaching their full potential.

1.1. Technology in Education

The development of educational technology has undergone significant transformation in line with digital advances, with Learning Management Systems (LMS) becoming a major innovation that enables the efficient management and delivery of learning materials [35]. LMS facilitates educators in organizing content, tracking student progress, and providing real-time feedback, thereby enhancing the effectiveness of the teaching and learning process [36]. In addition, e-learning and distance learning platforms have revolutionized access to education by removing physical and geographical barriers, allowing students to learn from anywhere and at any time [37] [38]. This freedom gives students the flexibility to manage their time and learning methods according to their individual needs and styles [39]. Digital connectivity also creates opportunities for educational institutions to reach a wider audience, increase inclusivity, and enrich the learning experience with diverse resources [40] [41].

The impact of technology on the learning process is vast and profound, especially in providing access to learning resources that were previously unevenly distributed, so that students can now easily access academic journals, educational videos, and interactive materials [42] [43]. This ease of access not only facilitates information retrieval but also enhances students' understanding and engagement with the material being studied [44] [45]. Flexibility in learning time and place is another advantage, where students can choose when and where they study, making learning more personalized and suited to individual rhythms [46] [47]. Interactivity has also increased thanks to online communication tools and social media, which enable students and lecturers to connect dynamically and facilitate online discussions, forums, and virtual study groups [48] [49]. These interactions enrich the learning experience and help students develop social skills that are important for the professional world [50] [51]. Thus, technology in education not

only increases access and flexibility, but also creates a more interactive and comprehensive learning experience, supporting the cognitive and emotional development of students simultaneously [52] [53].

1.2. .Emotional Intelligence in an Academic Context

Emotional intelligence (EI) is the ability to recognize, understand, and manage one's own emotions as well as those of others, introduced by Daniel Goleman, who emphasizes that a person's success is not only determined by IQ but also by the ability to interact effectively in complex social environments such as the academic world [54] [55]. In the context of higher education, students with good EI levels can adapt more easily, build positive relationships with peers and lecturers, and manage academic pressure and stress, thereby supporting an optimal learning experience and a supportive academic environment [56] [57]. The main components of EI include self-awareness, self-management, social awareness, and relationship management, where self-awareness is the ability to recognize and understand emotions and their impact on behavior, while self-management relates to the ability to control emotions in challenging situations [58] [59]. Social awareness includes empathy and the ability to understand other people's emotions, while relationship management emphasizes the ability to build and maintain positive relationships, which are very important in collaborative learning [60] [61].

The role of emotional intelligence (EI) in the learning process is crucial, as students with high EI are better able to cope with the stress and anxiety that often arise during their studies, thereby supporting psychological well-being and academic resilience [62] [63]. The ability to recognize and manage emotions helps individuals maintain focus and motivation, as well as enhance collaboration and a positive classroom atmosphere [64] [65]. Students who are sensitive to the emotions of others tend to find it easier to build bonds within study groups, support each other, and encourage the achievement of common academic goals [66] [67]. Teachers who understand and apply EI can create an inclusive learning environment that is responsive to students' emotional needs, thereby enhancing the overall learning experience [68]. The impact of EI on academic achievement is significant, with students with high EI tending to perform better academically, set realistic goals, overcome learning difficulties , and demonstrate perseverance in the face of challenges [69] [70]. In addition, EI contributes to the development of social skills such as communication and cooperation, as well as the use of effective stress management strategies to maintain productivity [71] [72]. Thus, the development of EI among students is not only beneficial for personal well-being, but also contributes to higher academic achievement and readiness to face future challenges.

1.3. Emotion Detection System

Emotion detection systems are advanced technologies designed to identify and interpret human emotional states through physiological and behavioral signals, such as facial expressions, tone of voice, body movements, and physiological responses such as heart rate or brain activity [73] [74]. In the context of education, this system serves to monitor students' emotional responses during the learning process, both in traditional and online classrooms, so that educators can adjust teaching methods in real-time to create a more effective and personalized learning experience [75] [76]. Facial expression analysis is the most common method, using computer vision and machine learning to recognize expression patterns such as smiles or confusion [77] [78]. Voice and tone recognition are also used to analyze vocal characteristics such as pitch and intensity to identify emotions such as joy or anxiety [79]. Advanced emotion detection algorithms now combine multimodal sensory data and deep learning techniques for more accurate and comprehensive emotion analysis, and have been integrated into educational platforms to provide real-time feedback on students' emotional states [80] [81].

Emotion measurement in education can be conducted through various complementary methods, where quantitative approaches use sensors and analytical software to collect objective data on students' emotional responses, as widely applied in recent studies [82] [83]. Meanwhile, qualitative methods such as questionnaires, interviews, and participatory observation provide deep insights into students' subjective emotional experiences and allow for exploration of the context and meaning behind emotional responses [83] [84]. Some educational institutions have begun to develop hybrid systems that combine automatic emotion recognition technology with self-assessment by students, thereby creating a more holistic approach to understanding the emotional dynamics of learning [85] [85]. These methods enable educators to identify emotional patterns that influence engagement and learning achievement, and to develop strategies for creating a more emotionally supportive learning environment [86] [87].

2. Research Method

In this study, the research methodology used included the following stages to develop an emotion-detection-based learning system for students:

2.1. Planning Phase (Problem Identification)

In this phase, the objectives, benefits, and scope of the emotion detection system development were defined in writing. The objective of this phase was to utilize emotion detection technology in education, particularly in improving the learning experience of students. The main focus of this research was the application of technology in learning methods, the development of teaching materials that are responsive to students' emotions, and how this system can be tailored to the individual needs of students to create a more inclusive and adaptive learning environment.

2.2. Planning (Design) Phase

At this stage, the design of the emotion detection system to be developed is modeled and planned in accordance with the desired objectives and benefits. An initial prototype of the system will be created in draft form, including the establishment of emotion recognition algorithms, user interfaces, and interaction logic. This design also includes markers and features that will be displayed in the system to ensure that the system can provide effective feedback to users based on the detected emotional state.

2.3. Development Phase (Design)

This stage involves the creation of a real prototype of the emotion detection system. In this phase, software containing emotion recognition algorithms, user interfaces, and interactive features will be implemented. A product catalog containing documentation and instructions for using the system will also be compiled so that students and teachers can understand how the system works properly.

2.4. Stabilization Phase (Testing)

This phase is where the system is tested under various conditions to identify any weaknesses. This testing will be conducted by involving students as users of the system to evaluate the effectiveness and comfort of their interaction with the system. These trials aim to identify limitations and areas for improvement in the emotion detection system, including detection accuracy and responses provided.

2.5. Implementation Phase

At this stage, the tested emotion detection system will be implemented more widely in the learning environment. Users, including students and teachers, will be given access to actively use this system. Feedback in the form of criticism and suggestions will be collected to gain useful insights for further improvement and development of the system.

2.6. Evaluation Phase (System Evaluation)

The evaluation phase aims to assess the effectiveness of the developed emotion detection system. This evaluation consists of determining the Research Sample. The evaluation of the use of this system will be carried out on students of the Electronic Engineering study program at the Faculty of Engineering, Makassar State University, Makassar, Indonesia. A total of 36 students will be sampled to collect data on their experiences in using the system and its impact on their learning process.

Through this methodology, the research is expected to produce an effective emotion detection-based learning system, increase student engagement and academic achievement, and make a significant contribution to the development of more responsive and adaptive education.

Testing of the emotion detection-based learning system for students can be done using the System Usability Scale (SUS), which is a questionnaire consisting of 10 items adapted from [88] and has been widely used in usability research on education and health systems [88] [89]. This SUS questionnaire uses a 5-point Likert scale, where respondents are asked to rate each item with the options "Strongly disagree," "Disagree," "Neutral," "Agree," and "Strongly agree," which is a common practice in measuring user perceptions of technology-based systems [90]. If respondents feel that they cannot find an appropriate response scale, they can choose the middle point on the scale, so that the measurement results still accurately reflect subjective assessments [91]. The use of SUS in this context allows for a systematic and standardized evaluation of the ease of use and user satisfaction with the developed emotion detection system [89].

Each statement item in the questionnaire has a different contribution score. The contribution score for each item ranges from 0 to 4, where for items 1, 3, 5, 7, and 9, the contribution score is calculated by subtracting 1 from the positive position on the scale. Conversely, for items 2, 4, 6, 8, and 10, the contribution score is calculated as 5 minus the position on the scale. Furthermore, to obtain the overall usable score of the system, the total contribution score must be multiplied by 2.5. This approach is expected to provide a clear picture of the level of acceptance and usefulness of the

emotion detection-based learning system among students, as well as help developers identify areas that need improvement to enhance the user experience.

Evaluation Statement
I believe I will use this system often.
I find this system rather difficult to operate.
I think this system is user-friendly.
I require help from technical personnel to operate this system.
I feel that the features of this system work together effectively.
I think this system has too many inconsistencies.
I assume that most people will be able to learn how to use this system easily.
I find this system quite cumbersome to handle.
I feel confident when using this system.
I think I need substantial training before I can operate this system properly.

2.7. Data Analysis with the SUS Approach

This study applies the System Usability Scale (SUS) as an evaluation instrument for emotion detection-based learning systems. SUS is a measurement tool developed by John Brooke in 1986, which has become the standard for assessing the usability of a technology system from the user's perspective. This method was chosen for its ability to provide a practical yet comprehensive usability assessment.

The evaluation questionnaire consists of ten questions designed to measure various aspects of the user experience. The main advantages of using SUS in this study include:

- Ease of Interpretation: The final score is presented on a scale of 0-100, which is easy to understand.
- Process Efficiency: No complicated mathematical calculations required
- Economical: Can be used without license fees
- Reliability: Its validity has been tested even with a limited number of respondents
- The assessment scale uses a five-point Likert system, ranging from "Strongly Disagree" (1) to "Strongly Agree" (5).

2.8. SUS Score Calculation Process

The scoring mechanism follows the standard SUS procedure:

- Each response has a contribution value of 0-4
- For positive statements (numbers 1, 3, 5, 7, 9), the score = scale value - 1
- For negative statements (numbers 2, 4, 6, 8, 10), score = 5 - scale value
- The total score is multiplied by 2.5 to obtain a final score of 0-100

This analysis is expected to reveal the level of acceptance of the system among students, as well as identify aspects that need to be improved for further development. The evaluation results will form the basis for improving the quality of this emotion detection-based learning system.

2.9. SUS Score Calculation Method for Emotion Detection-Based Learning Systems

In this study, the calculation of the system usability score follows the standard SUS methodology with the following modifications:

- Assessment Mechanism [88] :
- For odd-numbered statements (1, 3, 5, 7, 9):
- Score = Respondent's rating - 1
- Example: If the answer is 4 (Agree), score = 4 - 1 = 3
- For even-numbered statements (2, 4, 6, 8, 10):
- Score = 5 - Respondent's score

- Example: If the respondent answers 2 (Disagree), score = 5 - 2 = 3
- Calculation Formula:

$$\text{SUS Score} = 2.5 \times \sum_{i=1}^{10} \begin{cases} (R_i - 1) & \text{untuk } i \text{ ganjil} \\ (5 - R_i) & \text{untuk } i \text{ genap} \end{cases}$$

Explanation:

R_i is the respondent's score for the i^{th}question.

The final score range is 0–100.

Interpretation of Results:

The final score will be classified based on the following criteria:

- 80: Very Good
- 70-80: Good
- 60-70: Fair
- < 60: Needs Improvement

This method allows researchers to:

- Quantify the level of system usability
- Identify specific areas that need improvement
- Compare results with industry standards
- Provide data-driven development recommendations

These calculations will form the basis for evaluating the quality of emotion detection-based learning systems in supporting the learning process of students.

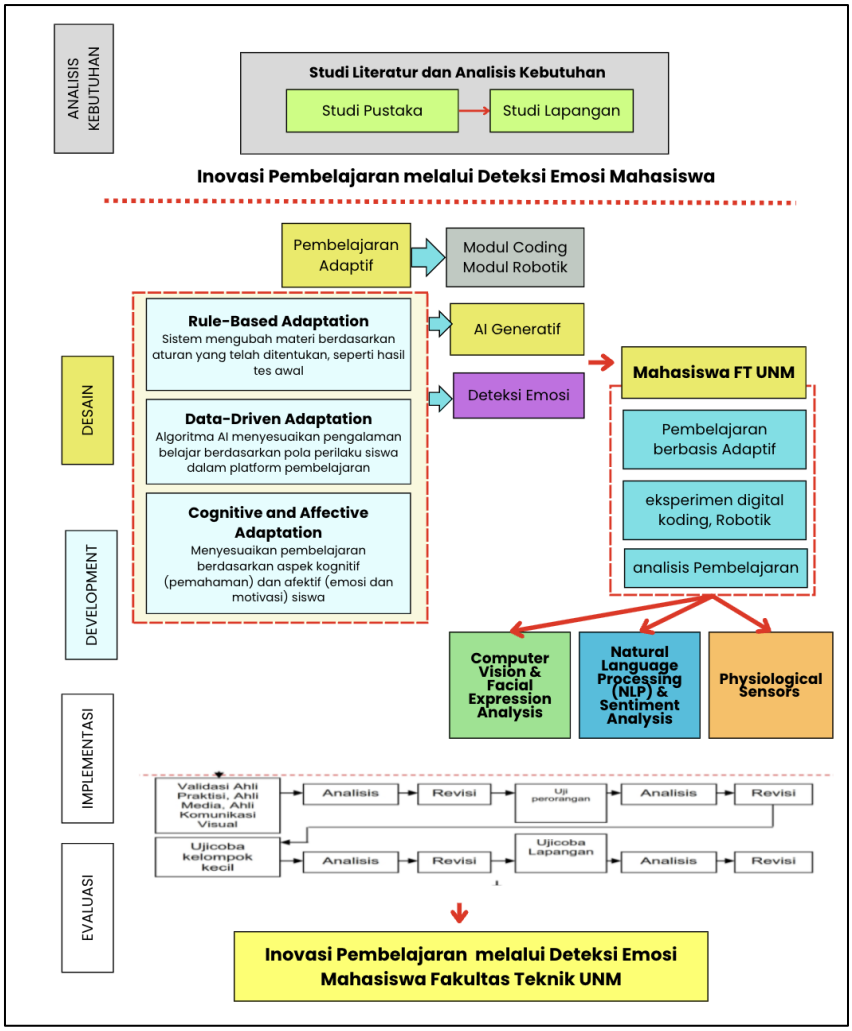

Figure 1 Research Block Diagram

3. Results and Discussion

3.1. Emotion Detection Application for Students

The learning media we developed is an innovative desktop application designed to enhance the learning experience of students through camera-based emotion detection technology (face-based emotion detection). This application needs to be installed on a computer, and to interact with the content provided, users will use their computer camera.

When using the application, students will be facilitated to detect their emotions through real-time face monitoring. This technology allows the application to analyze students' facial expressions and display models or information related to the emotions measured. The uniqueness of this face detection technology is that the objects or information displayed will depend on the emotions detected. This provides greater flexibility in the learning experience, as the content can be tailored to the user's emotional state.

The integration of emotion detection technology in learning media offers a highly engaging interactive experience for lecturers and students. With this approach, we can bridge the gap between theoretical and practical learning. Real and virtual elements combined in learning, such as through augmented reality (AR) technology, create a more dynamic and interactive learning environment that increases student engagement and participation in the learning process [93]. Meta-analysis studies show that AR integration significantly improves learning effectiveness, motivation, and student engagement compared to conventional methods [94] [95]. The use of AR has also been proven to strengthen conceptual understanding, improve learning outcomes, and encourage collaboration and social interaction among students [96] [97]. In addition, AR can increase student motivation, confidence, and learning satisfaction through immersive and

contextual learning experiences [98]. Thus, the combination of real and virtual elements through AR has great potential in creating a more engaging, participatory, and effective learning environment.

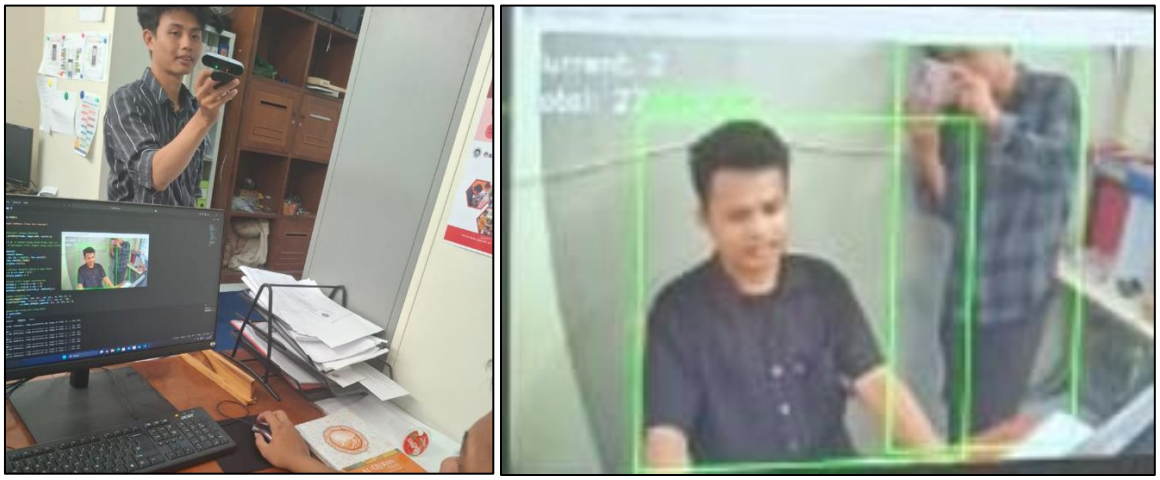

Figure 2 Student Emotion Detection in the Learning Process

Based on a systematic review, face-based emotion detection technology has been proven effective in education because it can improve material comprehension and provide accurate real-time feedback on student engagement [98] [99] [100]. The use of automatic facial emotion recognition systems has been shown to increase student motivation and participation in the learning process, both in physical and virtual classrooms, with high emotion detection accuracy of up to 95% [101] [102]. This emotion-detection-based learning medium is also capable of creating a learning environment that is responsive to students' emotional needs, making each learning session more meaningful, relevant, and adaptive to classroom dynamics [103] [104]. Thus, the integration of face-based emotion detection technology in education contributes significantly to improving the quality of student interaction, motivation, and learning outcomes.

3.2. Application Evaluation Results (AER)

In the context of developing an emotion detection-based learning system for students, it is important to understand that the System Usability Scale (SUS) serves as a tool that can measure the overall user experience, not just specific aspects of the emotion detection feature.

The user experience in using this learning system is a key factor that will influence the effectiveness of learning. By considering broader usability criteria, SUS helps us evaluate the extent to which the system can be understood and used by students to achieve their learning objectives.

We can see that emotion detection as an innovative feature in this system plays an important role in providing real-time feedback to students and teachers. However, the user experience is not only determined by the existence of this feature, but also by how it is integrated into the overall system. Some aspects that must be considered include ease of navigation, interface consistency, clarity of information, and system responsiveness.

By using SUS, we can collect data on how enjoyable and intuitive the system is for students to use in their learning context. The results of this SUS survey will provide valuable insights into the strengths and weaknesses of the system, as well as assist in the improvement and refinement of the emotion detection feature and other components

Through this approach, we not only assess the utilization of the emotion detection feature, but also how this feature contributes to the holistic experience of students during the learning process. Thus, focusing on usability will ensure that the system is accessible and can be used effectively by all users, thereby supporting better learning objectives and increasing student engagement. The following is the questionnaire respondent data.

Table 1 SUS Questionnaire Response Data from 36 Respondents

Respondents	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Resp1	5	1	4	2	5	1	4	2	5	1
Resp2	4	2	4	3	4	2	3	2	4	2
Resp3	5	2	3	1	5	1	5	2	4	1
Resp4	3	3	4	4	3	3	4	3	3	3
Resp5	4	2	4	2	4	2	4	2	4	2
Resp..36	3	3	3	3	3	3	3	3	3	3

Note: P1, P3, P5, P7, P9 are positive questions. P2, P4, P6, P8, P10 are negative questions.

Table 2 Calculation of Normalized Scores and SUS Scores per Respondent

Respondents	P1-1	5-P2	P3-1	5-P4	P5-1	5-P6	P7-1	5-P8	P9-1	5-P10	Total Normalized Score	SUS Score (Total×2.5 Total×2.5)
R1	4	4	3	3	4	4	3	3	4	4	36	90
R2	3	3	3	2	3	3	2	3	3	3	28	70
R3	4	3	2	4	4	4	4	3	3	4	35	87.5
R4	2	2	3	1	2	2	3	2	2	2	21	52.5
R5	3	3	3	3	3	3	3	3	3	3	30	75
R36	4	4	4	4	4	4	4	4	4	4	40	100
Average (Mean)											31.33	78.33
Median											30	75
Standard Deviation											6.81	17.02

Based on the table above, the average SUS score obtained is 78.33. Here is a general guide for interpreting SUS scores:

- < 50: Usability is very poor, major improvements are needed.
- 50 - 69: Usability is below average, significant improvement is needed.
- 69 - 79: Average usability, acceptable, but there is still room for improvement. (A score of 68 is considered the "acceptable" threshold).
- > 80: Good or very good usability.

Based on the data in Table 2, with an average score of 78.33, the developed learning system can be categorized as having good usability or above average. This shows that users (students) generally find the system easy to use, efficient, and enjoyable.

4. Conclusion

This study examines the development of an emotion detection-based learning system at the Faculty of Engineering, Makassar State University. In the context of evolving education, technology is increasingly important for enhancing the learning experience of students. Learning that is responsive to students' emotional needs can increase their engagement and academic achievement. Emotional intelligence (EI) is considered fundamental in this process because it helps students manage their emotions and adjust their learning methods.

The developed emotion detection system utilizes technology to monitor and interpret students' emotional states. With this approach, educators can make real-time adjustments to teaching methods, improving learning effectiveness. The research methodology applied involved several phases, from problem identification to system evaluation using the System Usability Scale (SUS). The evaluation results showed that this system has good usability, with an average score of 78.33, reflecting that students found the system easy to use and efficient.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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