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Research articles

Systematic literature review on emotion recognition AI feedback in mathematics games online among middle school students

Razid Ananda Siregar[1], Rahmah Johar[2], Mailizar[2]

Abstrak Penelitian ini mensintesis, menganalisis secara kritis, dan memetakan bukti empiris mengenai efektivitas umpan balik kecerdasan buatan (AI) dalam pengenalan emosi pada permainan matematika daring di kalangan siswa sekolah menengah. Menggunakan metode Systematic Literature Review (SLR), penelitian ini mengikuti pedoman PRISMA 2020. Proses penyaringan yang ketat terhadap 495 artikel dari basis data EBSCO, Springer Nature, dan Taylor & Francis menghasilkan 20 artikel yang memenuhi kriteria inklusi. Temuan sintesis menunjukkan adanya pergeseran tren penelitian menuju desain umpan balik yang secara sengaja memengaruhi keadaan emosional pengguna, yang didominasi oleh umpan balik berbasis emosi dan umpan balik berbasis metode penyampaian. Dampak dari umpan balik ini bersifat positif, khususnya dalam meningkatkan suasana hati dan kesejahteraan, serta memfasilitasi regulasi emosi secara langsung. Efektivitas tersebut dimoderasi oleh tiga faktor utama: desain sistem dan teknologi, faktor kognitif dan perilaku, serta konten dan situasi pembelajaran. Temuan ini menyiratkan bahwa perancang permainan daring harus mempertimbangkan arsitektur sistem yang secara aktif mengelola keadaan emosional siswa melalui dukungan sosial dan konten adaptif, lebih dari sekadar memberikan umpan balik performa. Karena literatur yang ditinjau didominasi oleh kajian kuantitatif, penelitian ini merekomendasikan agar studi di masa depan menggabungkan pendekatan kualitatif untuk mengeksplorasi pengalaman emosional subjektif siswa yang lebih bernuansa saat berinteraksi dengan AI.

Kata kunci *Emosi, Game matematika online, Kecerdasan buatan, Siswa sekolah menengah, Umpan balik*

Abstract This study synthesizes, critically analyzes, and maps empirical evidence regarding the effectiveness of artificial intelligence (AI) feedback in emotion recognition within online mathematics games among middle school students. Employing the Systematic Literature Review (SLR) method, this research utilized the PRISMA 2020 guidelines. A rigorous screening process of 495 articles from EBSCO, Springer Nature, and Taylor & Francis databases resulted in 20 final inclusion articles. The synthesis findings reveal a research shift toward feedback designs that deliberately influence the user's emotional state, dominated by emotion-based feedback and delivery method-based feedback. The impact of this feedback is positive, specifically improving mood and well-being and facilitating direct emotional regulation. The effectiveness is moderated by three main factors: system and technology design, cognitive and behavioral factors, and content and learning situations. These findings imply that online game designers must consider system architectures that actively manage students' emotional states through social support and adaptive content, beyond just providing performance feedback. Since the reviewed literatures are dominated by quantitative research, this study recommends that future research incorporates qualitative approaches to more deeply explore the nuanced, subjective emotional experiences of students interacting with AI systems.

Keywords *Artificial intelligence, Emotion, Feedback, Middle school student, Online mathematics games*

[1]Universitas Syiah Kuala, Darussalam, Indonesia, razidsrg6@gmail.com
[2]The Research Center of Realistic Mathematics Education, Universitas Syiah Kuala, Indonesia, rahmah.johar@usk.ac.id

Introduction

Mathematics learning is often fraught with emotional challenges, while it can be engaging, students frequently experience panic, helplessness, and math anxiety when solving complex problems (Contreras & Moreno, 2019). These negative emotional states, which stem from unpleasant teaching strategies or difficult concepts, directly impede students' logical thinking and problem-solving skills, which are crucial during middle school (Abdullah et al., 2022). Consequently, managing students' emotional states has been identified as an effective approach to overcoming learning difficulties and math anxiety (Zuhri et al., 2023). Emotions play a foundational role in building students' enthusiasm and attention (Hunt et al., 2022).

Conventional mathematics instruction often relies on static problem-solving methods, which can exacerbate math anxiety and fail to sustain student engagement over time (Fadda et al., 2022). To overcome these limitations, educational online games have emerged as a viable alternative. In recent years, the digital integration of educational online games has proven to have a significant positive impact on mathematics learning by increasing motivation and reducing boredom (Edén et al., 2024). Building upon this, the integration of Emotion Recognition Artificial Intelligence (AI) in online mathematics games has emerged as a promising targeted intervention (Lo et al., 2025). AI can provide emotionally responsive feedback that detects universal basic emotions and transforms negative responses into encouragement, thereby fostering emotional self-regulation and motivating students (Alsaiari et al., 2025).

The urgency for such emotionally responsive interventions becomes evident when examining the primary obstacles students face in mathematics (Lestari et al., 2025). Significant challenges in understanding basic math concepts are frequently rooted in math anxiety, a lack of deep conceptual understanding, and low motivation due to boredom (Debrenti, 2024). While online mathematics games inherently offer a positive impact on the general learning process (Barbieri et al., 2021), regular online games are often insufficient to address students' emotional barriers because the feedback provided is typically generic and not adaptive to students' real-time affective states (Liu et al., 2025). Addressing these specific affective barriers requires a more targeted strategy. In response to these challenges, actively exploring and managing students' emotions within these digital learning environments provides a highly effective approach to improving both their academic capabilities and their overall attitudes toward mathematics (Havnes et al., 2012).

Despite the increasing interest in and application of emotion recognition AI, there remains a significant research gap. Previous studies have explored emotional factors and digital games separately, leaving a critical intersection unreviewed: how AI-based emotional feedback specifically operates within middle school mathematics education. ("Al. I. Cuza, 2024; Beaumont et al., 2023; Contreras & Moreno, 2019). Furthermore, existing literature presents inconsistent findings regarding which feedback modalities are most effective in regulating negative emotions. Because of these scattered and inconsistent data, conducting this systematic review is essential. A critical review of prior studies reveals an underdeveloped understanding of how these technological interventions directly moderate emotional states in a mathematical context(Wisniewski et al., 2020).

Therefore, this Systematic Literature Review (SLR) aims to synthesize, critically analyze, and map the empirical evidence regarding the effectiveness of emotion recognition AI feedback in online mathematics games among middle school students (Qirom & Dadang Juandi, 2023).

This SLR will identify key patterns, the most frequently targeted emotion triggering factors, and the challenges and opportunities arising from the use of this technology, thus providing a solid theoretical and practical foundation for future research and development of educational technology.

To systematically address these gaps, the following research questions (RQs) were designed to examine the mechanism and impact of the AI intervention:
RQ1: What are the most researched types of feedback in online games?
RQ2: What is the impact of feedback in online games on students' emotions?
RQ3: What are the main factors that affect students' emotions by using a feedback system on students' emotions?

Methods

This study used the Systematic Literature Review (SLR) method to answer the three research questions posed, which was designed to identify and synthesize specific findings regarding the role of AI-based emotion feedback in digital mathematics learning (Ni et al., 2025). The study adopted the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines as the main framework for this study. The use of The PRISMA 2020 framework ensures the transparency and rigor of the review process in answering the research questions, especially in the process of identifying, screening, and selecting relevant literature (Page et al., 2021).

Eligibility criteria

Table 1 presents the inclusion (eligibility) criteria applied in this systematic review, covering five main domains: document type, language, subject, population and research objectives. These criteria were set to ensure that the studies reviewed were directly relevant to the research questions (RQs) of this review. To ensure that the reviewed works are accessible and of verified quality, this study only uses published research articles or conference proceedings that have undergone the peer-review process. This review strictly focuses on student emotions, AI feedback and online mathematics games. The main focus is on middle school students, as this age group is at the peak of emotion regulation development that can be significantly affected by AI interventions. The last and most crucial criterion is the Research Objective. The article should report findings on the impact and mechanism of AI-based feedback on student emotions through online mathematics games.

Table 1. Eligibility criteria

Criteria	Inclusion
Document	Published Research Articles or Proceedings
Language	English
Subject	Education, Emotion Recognition, Online games
Research Goal	Emotion recognition AI feedback in online games
Access	Full Access Article
Type of Research	Empirical data research
Year of Publication	2020-2025

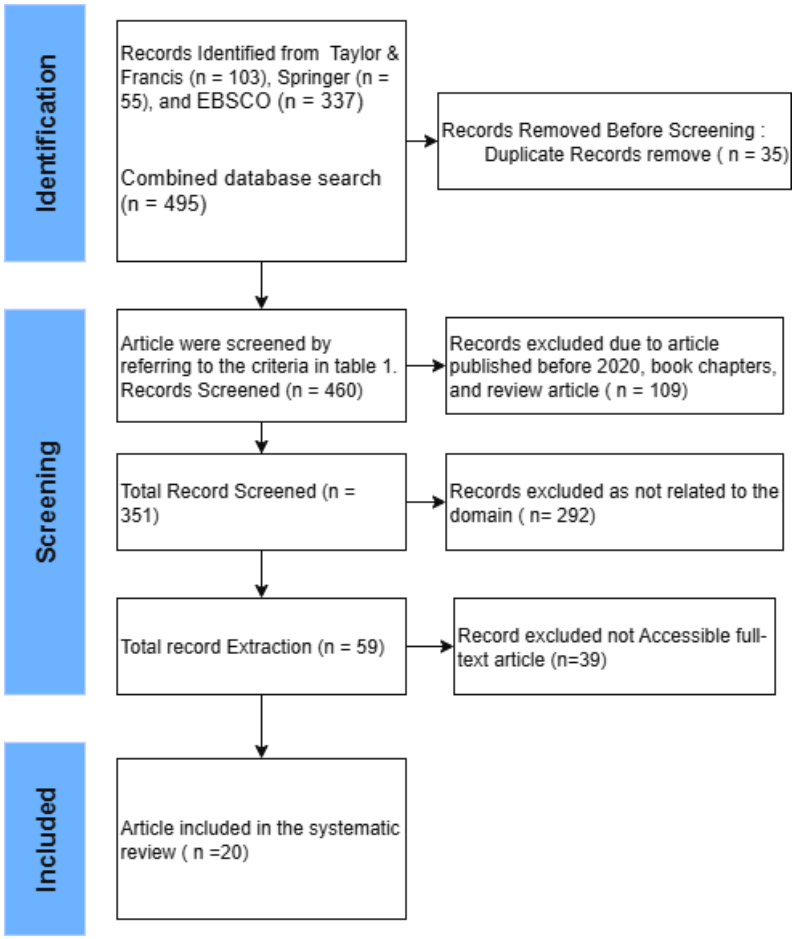

Figure 1. PRISMA diagram for emotional feedback topics in research database

Database and search terms

To identify relevant literature that met the inclusion criteria of this study, systematic searches were conducted on key databases, namely EBSCO, Springer Nature, and Taylor & Francis. Articles were retrieved using the following Boolean keyword combination: "Emotion Recognition AND AI Feedback AND Online Mathematics Games AND (Secondary School Students OR Middle School Students)" which was designed to ensure the suitability of the topic to our study framework.

Identification

Initial searches on the main academic databases, EBSCO, Springer Nature, and Taylor & Francis, using the specified search strings yielded a total of 495. At this identification stage, 35 duplicate articles were identified and excluded. The 460 articles then proceeded to the screening stage, where irrelevant articles (based on title and abstract) were excluded, leaving a number of articles for full analysis. The flow of this search process is depicted in detail in Revised PRISMA 2020 (Figure 1).

Screening

The screening process in this study was conducted in stages. After removing 35 duplicate articles, a total of 460 articles proceeded to the title and abstract screening stage. At this stage, 109 articles were excluded because they did not meet the eligibility criteria, leaving 351 articles that required a strong relationship with the research question. Of these 351 articles, 292 articles were excluded at this stage, leaving 59 articles for further extraction. At the next stage, 39 articles did not have full access to the article, therefore, only 20 articles met the inclusion criteria and were included for the data synthesis and coding process. The remaining all-access articles were reviewed in the final screening to determine whether they were appropriate for review. The third screening focused on articles that were able to answer all of the three research questions in this study. Articles that failed to answer even one of the research questions were removed. 292 were excluded at this stage, resulting in 20 articles included for review.

Based on the PRISMA flow, the final 20 inclusion articles were compiled for data extraction. The aim was to identify trends and gaps in the literature related to emotion-based AI interventions. Below in Table 2 is a complete list of the selected articles, categorized according to Method, Country, and Article Summary.

Table 2. Twenty selected articles

No	Citation	Country	Method	Article summary
1	Zhao et al. (2024)	China	Quantitative	A study on emotional design in smart product development, which aims to meet users' emotional needs and provide a positive experience.
2	Zhao et al. (2024)	Norway	Quantitative	This study provides strong theoretical support for emotional design practices, particularly in designing smart products under specific emotional scenarios.
3	Ghanouni et al. (2021)	Canada	Qualitative	A study focusing on the development and usability testing of an interactive motion game program designed to teach perspective-taking skills to children and adolescents.
4	Deori et al. (2023)	India	Quantitative	This study aims to evaluate certain characteristics of Koha and DSpace software videos uploaded to YouTube.
5	Fan et al. (2022)	China	Quantitative	Academic studies on the motivation for mobile learning (M-learning), Subject use of electronic devices (mobile phones and tablets) to engage in learning in various contexts
6	Fominska et al. (2024)	Malaysia	Quantitative	This study is based on the "Future Internet" vision, which aims to revolutionise digital interactions through the integration of advanced technologies such as AI and IoT.
7	Sato et al. (2024)	Japan	Quantitative	An experimental study investigating the phase relationship between melodic sound and breathing, focusing on the importance of timing control between music and breathing as a means of improving breathing awareness and control.

No	Citation	Country	Method	Article summary
8	Rodríguez-Galván et al. (2024)	Mexico	Mix Method	A study exploring changes in the style of written feedback provided by professors to students during the sudden transition from face-to-face to online learning due to the COVID-19 pandemic.
9	Sandefur & Manaster. (2022)	Indonesia	Quantitative	An experimental study investigating the role of positive performance feedback for users of Information and Communication Technology, taking into account differences in their levels of self-control.
10	Zhu et al. (2025)	China	Quantitative	An empirical study aimed at evaluating the effects of facial recognition technology on the happiness of citizens in China, integrating various social and technological theoretical frameworks.
11	Jiang et al. (2024)	Kanada	Qualitative	An in-situ study on the development and testing of smart textiles as an emotional regulation aid for healthcare workers, who are experiencing increased risk of stress and burnout due to the challenges of the COVID-19 pandemic.
12	Yang et al. (2021)	China	Quantitative	A hybrid recommendation model that addresses classic problems in recommendation systems by extracting user preferences through in-depth sentiment analysis at the sentence level from user reviews.
13	Desrosiers et al. (2021)	Sierra Leone	Quantitative	A study protocol aimed at developing a mobile health (mHealth) tool and conducting a random controlled trial for evidence-based family home visit interventions
14	Lin et al. (2024)	Singapore	Quantitative	A qualitative study examining how older adults interact with fitness trackers and how this interaction affects their level of physical activity.
15	Livanou et al. (2025)	England	Mix-Method	This study was successful in the co-production process and demonstrated that serious games have significant potential to help young people manage their affective conditions.
16	Edén et al. (2024)	Sweden	Mix-method	This study introduces VoiceBack, a voice-based feedback system powered by Artificial Intelligence (AI). The system is conceptualized to support customers and online travel agencies during the travel booking process.
17	Finlay-Jones et al. (2023)	Australia	Quantitative	This study presents important background information on the psychological vulnerability faced by adolescents living with chronic physical conditions.
18	de Souza Jeronimo et al. (2022)	Brazil	Mix-method	A study comparing two social robot models in running the same Human-Robot Interaction application, focusing on the context of music education for children aged 9-11 years.
19	Middleton et al., (2022)	USA	Quantitative	A study that examines the complex relationship between various aspects of engagement in mathematics among first-year high school

No	Citation	Country	Method	Article summary
				students in the United States, using the Control Value Theory theoretical framework.
20	Stovner et al. (2021)	Norway	Qualitative	An observational study examining how mathematics teachers provide feedback in the classroom, comparing situations where procedural feedback is given versus conceptual feedback or mathematical practice.

Data analysis

The 20 articles that passed the final inclusion criteria were then comprehensively analyzed using a defined Literature Review Coding Framework. This framework, which was designed to answer the study's Research Question (RQ), consists of five main dimensions, namely: Type of Intervention/System, Subject, Population/Education Level, Research type, and Outcome Effect. A detailed explanation of each of coding dimensions is as follows (Table 3).

Type of intervention/system

This coding dimension serves to precisely classify the nature and main functions of the technologies that are the subject of each study. This classification is crucial as this study focuses on AI-driven Feedback mechanisms in a learning context. We divide the interventions into several main categories, which include: Serious Games and Educational Apps (including mobile math games), Text/Voice-based AI Feedback Systems, Health Tracking Interventions, and Data Analysis Systems. This coding allowed us to accurately gauge the portion of the literature that directly examines the integration of Emotion Recognition in educational games, thereby mapping and justifying the research gaps that are the main focus of our experimental interventions.

Subject

This coding dimension served to identify the academic subject area or functional domain that was the focus of the intervention in each article reviewed. This classification allowed us to map the distribution of research and determine how large a portion of the literature directly applied AI emotion-based feedback to the context of Mathematics, the central subject area in this study and how large another portion applied to domains such as Health and Wellbeing, Information Systems, or Other Educational Fields.

Population/Education level

This dimension of coding aims to classify the age group and educational context of the research subjects examined in each article. This classification is essential to verify the appropriateness of the findings to the main focus of this thesis, which is middle school students. The categories used include subjects in: Primary or Middle Education, Higher Education, Clinical Population, and General. Thus, this coding allowed us to clearly identify and map the literature that empirically focuses on the adolescent age group.

Research type

This coding dimension serves to classify the methodology adopted by each article, identifying the structure and strength of scientific evidence of the findings presented. We classified studies into three main categories: Quantitative, which aims to measure variable relationships; Qualitative, which aims to explore the depth of meaning and experience and Mixed-Method, which combines both approaches. This classification is critical to this SLR as it allows us to map the distribution of studies and unequivocally identify the need for credible quantitative experimental research (RCT) to test the causal relationship between AI feedback and learning outcomes-a significant gap in the literature that is often dominated by descriptive or developmental studies.

Tabel 3. Coding framework

Dimension	Category
Type of Intervention/System	Serious Games Educational Games AI Feedback System Health Tracking Data Recommendation
Subject	Math Health Welfare Information Systems Education (general)
Population/Education level	Middle School Higher Education Adult/General Special Populations
Research Type	Quantitative Survey Research Experimental Research Qualitative Exploratory Research Mixed Methods
Outcome effect	This dimension depends on the information in the articles

Findings and Discussion

A total of 20 papers were chosen through a rigorous search and selection procedure based on the goals and eligibility criteria of this study. Table 2 summarizes all selected articles based on the author's name, year of publication, country, and article summary.

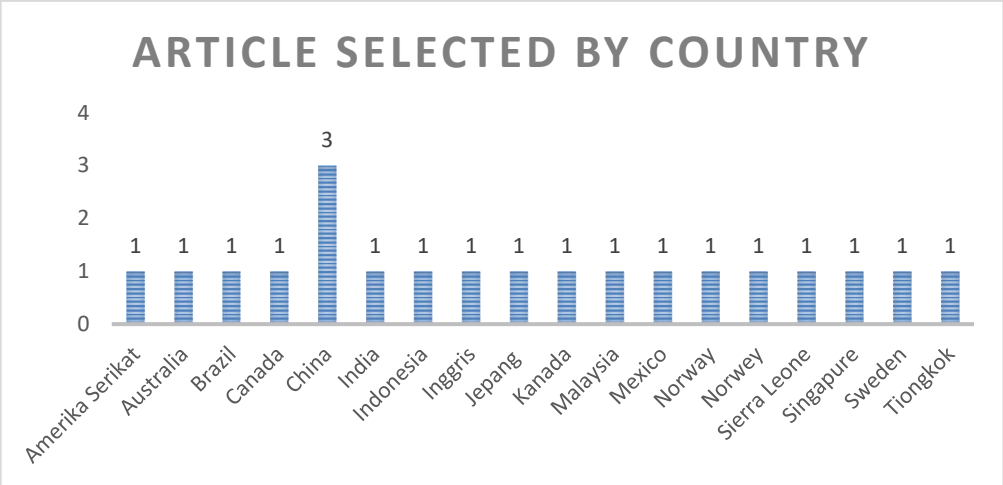

Figure 2. Number of articles based on countries

The geographical distribution of the 20 selected articles in Figure 2 reveals that China is the leading contributor, producing the highest number of studies. This dominance likely reflects the country's extensive national policies and massive investments in integrating Artificial Intelligence into its educational infrastructure. Conversely, the remaining articles are widely dispersed across various countries, with no single nation producing more than one or two studies. While this indicates a widespread global interest in AI-based emotional feedback, this fragmented distribution suggests that, outside of a few tech-forward regions, research at the intersection of AI, emotion regulation, and mathematics learning remains exploratory and lacks centralized, established research clusters.

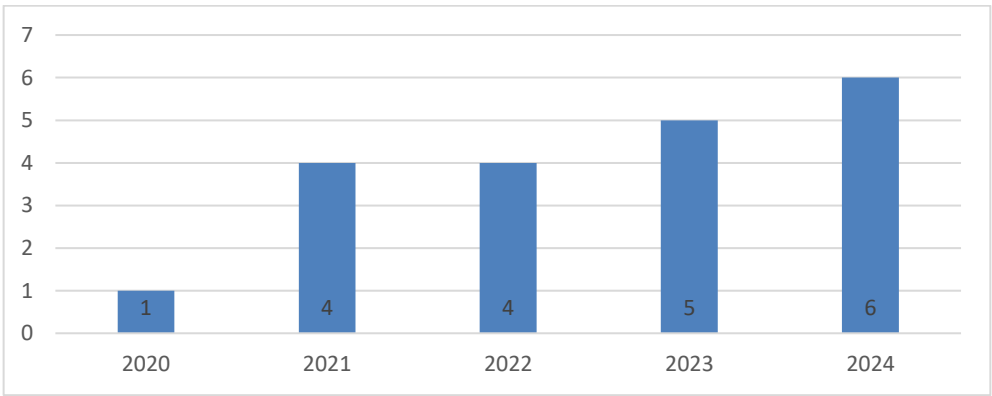

Figure 3. Number of articles based on year of publication

Figure 3 illustrates a clear ascending trend in publications from 2020 to 2024. The highest output occurred recently, with 6 articles in 2024 and 5 articles in 2023. This upward trajectory closely aligns with the post-COVID-19 acceleration of digital learning environments and rapid breakthroughs in AI emotion-recognition technologies, such as computer vision and machine learning. The concentration of literature in the last two years not only underscores the high novelty of this topic but also signifies a critical transition in the field: research is moving rapidly from theoretical frameworks into the active implementation and empirical testing of AI feedback systems in digital mathematics classrooms.

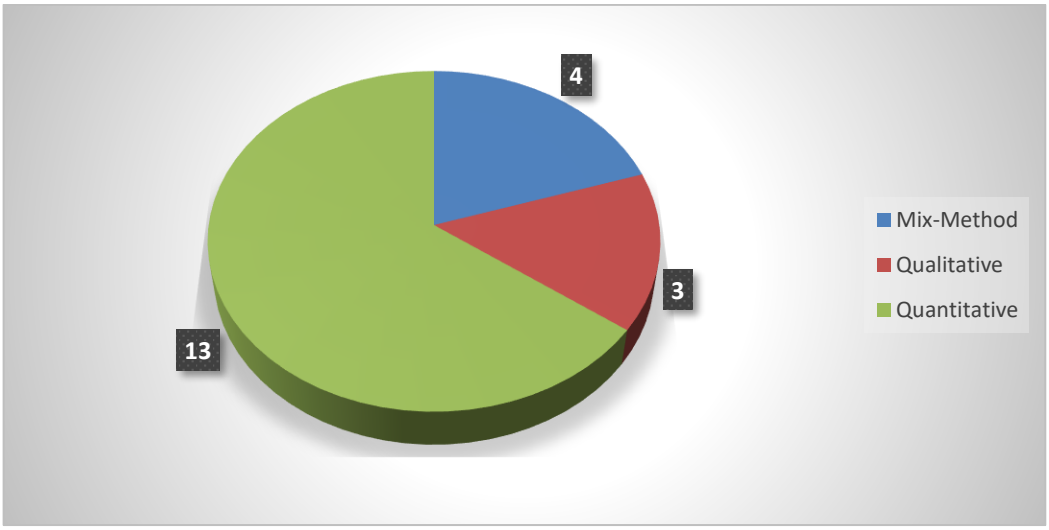

Figure 4. The number of articles based on the research method used

In terms of research methodology, Figure 4 reveals a strong dominance of quantitative approaches, accounting for 65% (13 *articles*) of the reviewed literature. Mixed-methods were utilized in 20% (4 *articles*), while qualitative methods comprised only 15% (3 *articles*). The reliance on quantitative designs is logically tied to the technical nature of Emotion AI, which typically measures emotional states through quantifiable biometric data or standardized psychometric scales for math anxiety. However, this methodological preference highlights a potential bias and gap in the current literature. While quantitative studies effectively measure the outcomes of AI interventions, the lack of qualitative research means the field may be overlooking the nuanced, subjective experiences of students. To fully understand the mechanisms of AI-based emotional feedback in mathematics learning, future studies must prioritize qualitative or mixed-methods to explore how and why students emotionally interact with these digital systems, beyond mere numerical outcomes.

RQ 1: What are the most researched types of feedback in online games?

To systematically address RQ1, the extracted data regarding feedback interventions from the reviewed articles were classified into four main categories. To avoid conceptual ambiguity, these categories are defined as follows: (1) Emotion-based feedback, defined as interventions specifically designed to respond to or alter the user's affective; (2) Delivery method-based feedback, which categorizes feedback by its sensory modality or technological mechanism; (3) Content-based feedback, referring to the pedagogical or instructional substance provided to the student; and (4) Social-based feedback, which involves simulated or actual human interaction elements, such as pedagogical agent expressiveness or peer support.

Table 4. Types of feedback

Categories of feedback types	Feedback subtype	Supporting journal	Total
Emotion-based	Sentiment (Positive/Negative) Reinforcement.	2, 5,6,8,9,12,15	7
Delivery method based	Vibrotactile Audio	4,7,9,11,14,16,18	7

Categories of feedback types	Feedback subtype	Supporting journal	Total
	Sound-based Non-verbal Biofeedback Real-time.		
Content-based	Procedural Conceptual Substantive Fine-tuned	3,13,20	4
Social-based	Teacher/Peer Support Personal Agent Expressiveness	11,14,18,19	4

As presented in Table 4, the literature exhibits a strong concentration on specific feedback mechanisms. The most dominant trends are delivery method-based feedback and emotion-based feedback, each featured prominently in 7 studies. In contrast, social-based and content-based feedback were less frequently the primary focus, identified in 4 and 3 studies respectively.

A deeper relational analysis of these findings reveals that these categories are highly interdependent within the context of AI-enhanced digital games. The equal dominance of emotion-based and delivery-based feedback indicates that current research does not merely explore *what* affective message to convey, but intricately investigates *how* to deliver it effectively. For instance, systems utilizing AI for emotion recognition heavily depend on advanced sensory modalities, such as real-time audio cues or vibrotactile alerts to provide immediate, non-intrusive reinforcement.

Rather than a chronological shift, this distribution highlights the current thematic priorities in the field. The strong emphasis on emotion and delivery modalities over purely pedagogical content suggests that researchers view feedback in online mathematics games primarily as an active mechanism for psychological regulation. In overcoming math anxiety or boredom, the most researched feedback types are those that function as responsive affective agents, utilizing multi-sensory technologies to address and regulate students' emotional states instantaneously during mathematical problem-solving.

RQ2: What is the impact of feedback in online games on students' emotions?

To address RQ2, an analysis of the extracted data reveals that the impact of AI-based feedback on students' emotions is highly nuanced and intricately linked to the specific type, timing, and modality of the intervention. Rather than producing a uniform emotional response, the literature indicates a spectrum of impacts ranging from immediate negative emotion mitigation to long-term affective well-being.

Table 5. Impact of feedback based on emotion

Emotional impact category	Description	Supporting journal
Increased Positive Emotions & Well-Being	Positive feedback and web-based interventions consistently improve Joy Well-Being Mood in line with the function of reinforcement to motivate.	8, 9, 15, 17

Emotional impact category	Description	Supporting journal
Immediate Negative Emotion Regulation	Vibrotactile/Audio Feedback shows a positive impact on immediate emotion regulation effectively Reduces sadness and mitigates negative emotions such as anxiety/anger in adolescents	8, 11, 15
Central Affective Mechanism	Personal and social feedback influence users' In-the-Moment Affect and Affective responses These emotional responses serve as central mediators linking feedback to motivation and behavior change	6, 14, 19
Impact Limitations	Web-based feedback interventions have shown limitations in addressing more complex emotion regulation difficulties Suggesting that positive impacts are often limited to milder or situational emotions.	17

A critical synthesis of the findings reveals that AI feedback in mathematics games serves a dual function. Firstly, contrary to generalized assumptions of purely positive outcomes, a primary impact of specialized feedback is the mitigation of negative and mixed emotional states, such as math anxiety, frustration, and cognitive overload. Studies focusing on delivery method-based feedback, specifically real-time vibrotactile and audio cues what demonstrate significant efficacy in immediate negative emotion regulation. Because this feedback is delivered instantaneously upon detecting user distress, it acts as an "affective interrupt" effectively preventing situational frustration from escalating into paralyzing anxiety or anger during complex mathematical problem-solving.

Secondly, studies examining emotion-based and social-based feedback highlight a strong correlation with increased positive emotions and overall affective well-being. When systems utilize personalized positive sentiment and reinforcement, they effectively elevate joy and mood. In this context, feedback operates as a central affective mechanism. It goes beyond simply correcting a mathematical error; it mediates the user's psychological state, transforming moments of failure into opportunities for motivation and behavioral persistence.

However, a comparative analysis across the literature also exposes significant contextual limitations. The emotional impact of AI feedback is heavily dependent on the severity of the user's emotional state. As noted in Study 17, while web-based feedback interventions are highly successful in regulating mild, situational emotions triggered by immediate gameplay challenges, they lack the capacity to address more complex, deep-rooted emotion regulation difficulties.

To provide a clear pictorial representation of these interconnected findings, a thematic map was developed based on the synthesized literature (Figure 5). This framework illustrates how specific feedback types lead to distinct immediate emotional impacts. These immediate impacts then converge to function as a central affective mechanism that drives student motivation, with all interactions operating within the boundaries of contextual limitations.

In conclusion, the impact of AI feedback on students' emotions is profound but bounded. Its most significant contribution lies in its capacity to provide immediate, real-time emotional regulation through multi-sensory modalities, thereby reducing math anxiety and fostering a positive affective environment. However, its effectiveness is strictly tied to the context of situational learning and the specific design mechanisms employed.

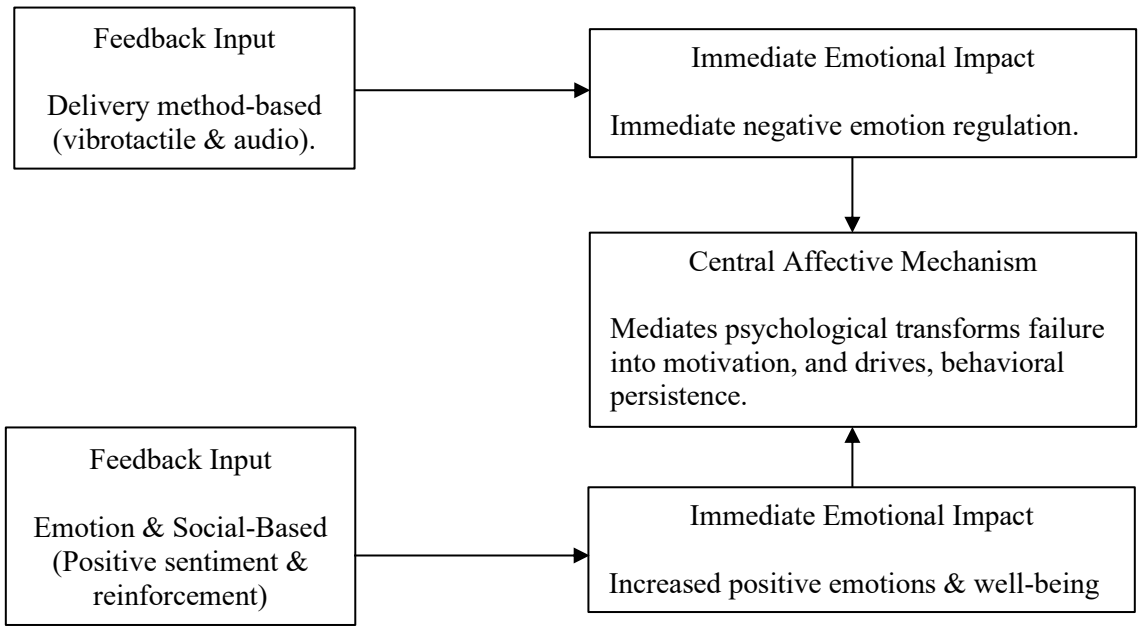

Figure 5. Thematic map of AI feedback impacts on students' emotions

RQ3: What are the main factors that affect students' emotions by using a feedback system on students' emotions?

To systematically address RQ3, a thematic synthesis was conducted on the extracted data. The findings identify three main categories of factors that influence students' emotions through the use of technological feedback systems. These factors include elements integrated into the system design, the internal psychological state of the user, and the broader instructional context.

Table 6. Category of factor

Category factor	Description	Supporting Journal
System Design & Technology Factors	This factor focuses on the feedback mechanism itself Sensory Mechanisms such as Vibrotactile Sentence Level Sentiment Analysis Agent Embodiment Features.	11, 12, 16, 18
Cognitive & Behavioral Factors	Factors related to the user's internal state and interaction with feedback Goal-related Decisions program Engagement and Retention issues.	9. 14, 17
Instructional Content & Situation Factors	Factors that highlight what and when feedback is given in academic contexts Complex Instructional Situation Teacher/Peer Support as social feedback.	8, 19, 20

As shown in Table 6, the identified categories are: (1) System design & technology factors, (2) Cognitive & behavioral factors, and (3) Instructional content & situation factors. The

interpretation of how these factors interrelate to affect students' emotions is further elaborated in the Discussion section.

The findings of this systematic review indicate that the effectiveness of AI-based feedback systems in influencing students' emotions does not rely on isolated variables. Instead, it depends on a complex, interdependent ecosystem involving technology design, user psychology, and instructional context. A cross-study synthesis of the literature reveals a hierarchical relationship among these factors, which this review conceptualizes into an integrated affective feedback model. Rather than operating independently, these factors interact in a sequential manner, beginning with the system design as the foundational trigger.

As the trigger, system design and technology are identified as the most dominant and foundational factors (Studies 11, 12, 16, 18). In order to achieve a significant emotional impact, systems must have advanced capabilities to process and respond to emotions. Advanced AI-driven mechanisms, particularly real-time multi-sensory delivery like vibrotactile feedback, are the primary initiators of immediate emotional shifts. This technological capability is crucial for feedback to be delivered non-intrusively and instantaneously during mathematical problem-solving.

However, technological capabilities alone are not enough; they are subsequently filtered by cognitive and behavioral factors, as the intervention is significantly moderated by the student's internal state (Studies 9, 14, 17). The success of feedback interventions depends on internal conditions such as students' level of self-control and how they make goal-related decisions (Hunt et al., 2022). These factors act as a psychological bottleneck. The biggest challenge in implementation is engagement and retention; feedback will have no emotional impact if students are not motivated to use the system on an ongoing basis (Yang et al., 2021).

Finally, the instructional content and situational environment are required to sustain the emotional impact (Studies 8, 19, 20). This factor underscores the importance of the quality of the feedback itself and its social context (Liu et al., 2025). The system should integrate social support and ensure positive feedback is delivered at the right instructional situation (Fisher et al., 2023). Ultimately, effective emotional regulation through AI feedback in online mathematics games relies on a continuous interaction where technological precision must be perfectly aligned with the user's cognitive readiness and pedagogical empathy.

Conclusion

This systematic review highlights that Emotion-Based and Delivery Method-Based feedback are the most prominently researched modalities in interactive systems, effectively utilizing positive reinforcement and sensory cues to manage students' emotional states. These AI-driven feedback mechanisms function as central affective agents that yield measurable positive impacts, specifically by improving overall mood and providing immediate regulation of negative emotions. Because this effectiveness is intricately moderated by system design, cognitive-behavioral traits, and instructional contexts, it is imperative for online game developers to design architectures that actively manage affective states through adaptive content and social support, rather than merely evaluating academic performance.

Despite these significant findings, current AI feedback is primarily limited to addressing mild, situational emotions rather than deep-rooted regulation difficulties. Recognizing the methodological limitations of this review, which is based on a relatively small sample of 20 predominantly quantitative articles, future studies must expand search databases to enhance the

robustness and generalizability of these findings. Furthermore, subsequent research should incorporate qualitative designs to deeply explore students' subjective emotional experiences, and examine quantitative academic data to evaluate the direct correlation between AI-based emotional regulation and actual mathematics learning achievements.

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