

# AI-Based Feedback Systems and Student Learning Outcomes in Higher Education: A systematic review (2020-2025)

Zhichao Xiong <sup>1,\*</sup>, Mohamad Nizam Nazarudin <sup>1</sup> and Yan Tian <sup>1</sup>

<sup>1</sup> Faculty of Education, Universiti Kebangsaan Malaysia, Bangi, Selangor, 43600, Malaysia

\* Correspondence author: zcxiongedu@163.com

**Abstract:** This is a systematic review of the topic of AI-based feedback systems and their impact on student learning outcomes in higher education. Through Scopus, Web of Science (WoS) and ERIC, 93 records were obtained and filtered on the PRISMA principles, leaving 15 studies that were included in the study samples. The review mentions six broad categories of AI feedback tools, namely automated writing assessment systems, intelligent tutoring systems, generative AI-based feedback, learning analytics dashboards, chatbots, and AI-assisted grading systems. Throughout these tools, the learning outcomes that were reported were academic performance improvement, improvement in writing, conceptual understanding, engagement and motivation and self-regulated learning. The results also show that AI-based feedback can also be implemented in various fields, with the best representation of them being social sciences, then education, engineering, and health sciences. Overall, the review highlights the increasing importance of AI responses to improve instructional processes, help learners to become more independent, and offer scalable, time-sensitive and individualised feedback that can give some credible perspectives on the future of teaching and learning in higher education.

**Keywords:** AI-based feedback systems; higher education; student learning outcomes; self-regulated learning; systematic review

## 1. Introduction

AI can already be called the new direction in higher education, particularly regarding the expansion of universities using digital technologies to overcome old issues with instruction, grading, and student services. Artificial intelligence technologies are now taking a centre stage in the learning process, especially applications that seek to provide timely and personalised feedback [1,3]. The reason why they are rapidly adopted is associated with the increase in enrolments, more decisive demands of instant direction, and the ongoing move toward blended and online learning [3-5]. With the trend toward more flexible and technology-based instructional models in institutions, AI-based feedback systems have become a feasible solution to enhancement of academic feedback quality, accessibility, and consistency.

One of the remaining vital aspects of student learning is feedback. It assists learners to track their gains, identify areas of lack of knowledge, and should know what to do to improve. Specific, relevant, and timely feedback can encourage greater learning of course content and reinforce the ability of students to be self-regulated learners [2]. Nevertheless, most institutions of higher learning cannot afford to sustain these standards. Poor time planning, staffing and large assessment loads frequently makes instructors unable to offer immediate and extensive feedback. Students often complain of protracted periods before their work is assessed, and teachers are increasingly under a strain to cope with large amounts of paper. All these difficulties have given rise to increased activity in automated and semi-automated systems that are able to assist students and teachers.

The type of AI-generated feedback includes a vast selection of tools, such as automated writing analysis, intelligent tutor platforms, and conversational agents, as well as dashboard-like analytics



platforms. These systems examine student input, determine mistakes or misunderstandings and generate formative feedback near real-time. The generation of machine learning and natural language processing, as well as the creation of large language models, in particular, significantly increased their ability to analyse student work and provide personalised advice. Consequently, AI feedback has developed beyond basic error fixing to more advanced forms, such as conceptual explanations, specific hints, motivational messages, and guided revision directions.

In addition to technological development, the increasing utilization of AI-driven feedback is in line with the larger education agenda that focuses on equal access, quality, and sustainable development throughout higher education. Institutions are supposed to support the growing diversity of student population, as well as equip students to be able to work in the rapidly evolving work settings. With responsible use, AI feedback may be used in these directions, as it will provide students with constant chances to improve their learning and instructors with additional time dedicated to complex teaching activities. Their scalability especially comes in handy in large enrolment courses and in professional programmes that are hard to deliver personalised attention using traditional methods.

Nonetheless, the evidence of AI feedback systems research is rather muddled despite their potential. Numerous researches note quality of writing, conceptual learning, student engagement, and confidence among learners. There are complaints about lack of accuracy, ethics as well as over-dependence by students on automated instructions. These controversies have been aggravated by the rapid proliferation of generative AI since 2022, with newer systems having the ability to provide the precise feedback when applied while also presenting new drawbacks, including hallucinated information, bias, or lack of transparency. These points help recognize the necessity to investigate the real impact of AI feedback on learning outcomes using systematic and current evidence.

Even though some prior reviews have discussed AI in education in a broader sense, a limited number have specifically discussed AI-generated feedback in the higher education field [6]. Numerous available reviews focus on automated grading or overall, AI adoption, creating knowledge gaps regarding the impact feedback-specific tools have on academic performance, learning behaviours, and disciplinary practices. Moreover, the unique requirements of higher learning, including difficult writing assignments, disciplinary complexity, and critical thinking, require expert exploration [7]. As of 2020, numerous empirical studies have also been published, as the application of AI feedback tools has become a fast-developing tendency as the institutions adjusted to the remote and hybrid learning profiles. Such studies will provide valuable data on the real work of AI systems in real teaching environments, and a systematic review is urgent and required [9,17].

The proposed systematic review thus intends to pool together empirical studies regarding AI-based feedback systems in higher learning between the year 2020 and 2025. The review discusses the category of AI feedback system, results of learning they affect, and the application of AI feedback in the areas [5,20]. This emphasis permits the better comprehension of new trends, the differences in disciplines, and the pedagogical roles played by AI feedback tools. It also points to gaps in literature, which guides the field of future research, as well as institutions in need of integrating AI into assessment and teaching practices.

The following research questions guide this review:

**RQ1:** What types of AI-based feedback systems are used in higher education?

**RQ2:** What learning outcomes are associated with these systems?

**RQ3:** What fields of study employ AI-based feedback, and what gaps exist?

### *1.1. Trends in AI-Based Feedback Systems*

The last ten years saw a rise in research on AI-supported feedback, and the trend has been growing with the progress in natural language processing and neural network-based architectures [13]. Early AI feedback systems majored on structured exercises or simple language tasks, though recent systems assist with more complex academic tasks like argumentative writing, design projects, and scientific problem solving. Research in various education settings emphasise that such students receive instant and practical feedback which is effective in demystifying the misconceptions, reinforcing the conceptual understanding and cementing revision strategies [8]. In addition, educators appreciate AI tools due to their potential to cut administrative burden, facilitate formative assessment, and provide insights into student learning patterns.

In spite of these events, there are still some concerns about the quality of the AI feedback, its uniqueness to course objectives, and the loss of human judgment in tricky tasks. Due to the advancement in the field of AI models, bias, transparency, and ethical usage have become central subjects of concern [10,17]. Such contradictory results indicate that systematic synthesis is required, especially on the context of higher learning where academic integrity and discipline are supposed to be high.

## *1.2. Trends in AI-Based Feedback Systems*

The study of AI-based feedback systems has grown fast within the field of higher education, owing to machine learning and natural language processing progress. The initial systems lacked further and more adaptive features by offering individualised advice and only underlying fundamental elements of error detection [11]. This kind of systems now scan the student writing, program the steps to solve problems, and come up with extremely detailed formative feedback that enhances independent study. According to various research, students enjoy the immediate feedback provided by AI, especially in online or blended classes when they might lack access to the instructor [12]. The fact that AI systems can provide the same guidance to mass cohorts also makes them appealing to courses with high stakes requirements.

In addition to the benefit of students, educators are also more heavily relying on AI to help control the workload and enhance the quality of feedback. The automation will assist in detecting the typical errors, underlining the false assumptions, and pointing out the initial remarks which experts can refine [14]. This complimentary role will enable instructors to prioritize higher-order teaching activities and yet have timely feedback loops. Yet, studies also note the problem, such as the occasional inaccuracy, the inability to grasp the context, and the fear of excessive reliance on automated recommendations. The question of fairness and unethical use has become increasingly apparent, particularly as the range of generative AI models that have the capability to generate properly human-sounding text has expanded [13,16]. These ambivalent results reflect that more transparent integration practices and further assessment of AI feedback systems in actual instruction have to be made.

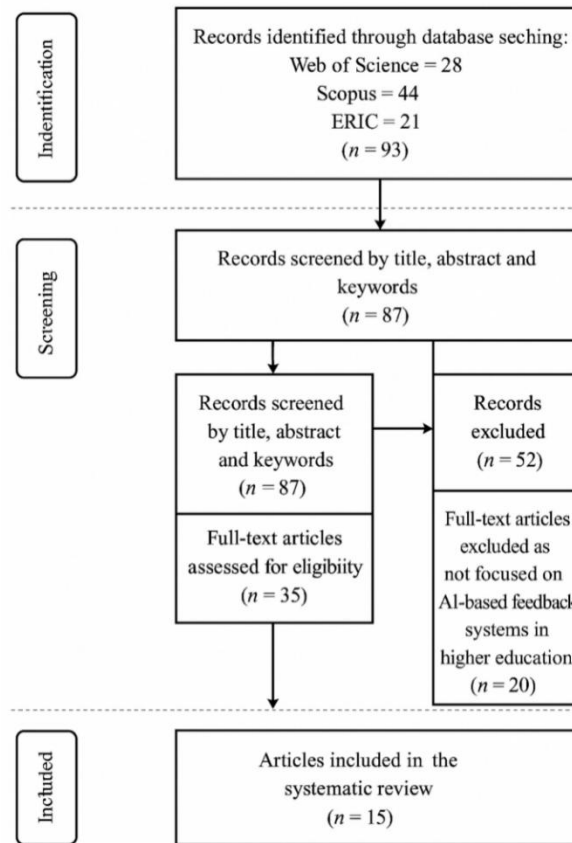
## *1.3. Reviews on AI-Based Feedback*

Several reviews have investigated the role of artificial intelligence in education that is less specific to higher education and AI-generated feedback. The reviews available tend to focus on automated grading, intelligent tutoring or the overall adoption of AI and give less attention to feedback [15]. Although these studies emphasize the potential of AI to enhance learning effectiveness and engagement, it rarely focuses on the effects of feedback-specific devices on quantifiable learning outcomes like performance, self-regulation, or motivation. Recent reviews speak about the increased application of generative AI in pedagogy, but many feature research in the K-12 level, which is less relevant to higher education where learning projects are more advanced and disciplinary demands are stiffer [17,18].

Other reviews are based on the pedagogical benefits of AI feedback but fail to reflect the accelerated technological pace after 2020, such as the introduction of large language models that are distinct from the previous systems [19,26]. Thus, there is a risk that the current syntheses are not a reflection of the current capabilities, risks, and implications of their pedagogical consequences. In addition, very few reviews focus on the AI feedback, specifically on higher education, although the reliance on online evaluation has been on the rise during and after the pandemic. This gap shows that a recent and focused synthesis of empirical studies is necessary as of 2020-2025 [20]. The current review addresses this demand by exploring how the learning outcomes of AI-based feedback systems are influenced in particular higher education settings [21,22].

## **2. Methods**

This systematic review is based on the Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA) method, a combination of four key procedures: identification, screening, eligibility, and inclusion, described in the PRISMA flow diagram of this study, see Figure 1 [23]. PRISMA has gained a vast amount of use in research due to its understanding and organization, as well as its applicability in a wide range of areas of interest. PRISMA offers a clear and repeatable system of choosing and assessing empirical studies on AI-based feedback systems in higher education in the context of the given study. As such, the purpose of this review and the procedures carried out during the systematic review process is presented in the following sections [24-27].



**Figure 1.** PRISMA systematic review diagram

### 2.1. Identification

The Identification process is the first phase in this systematic review and it is presented in the PRISMA guidelines. Three databases were chosen as they are famous in indexing high-quality educational and technological research Web of Science (WoS), Scopus, and the Educational Resources Information Centre (ERIC) [28]. To frame the main concepts of the study, the key words that were applied during this review were well designed to present the main concepts, i.e., artificial intelligence, feedback systems, and learning outcome in higher education [29,30]. Keywords pertaining to AI-assisted feedback and automated evaluation and university learning performance were employed to cover all the pertinent literature.

Table 1 below presents the search strings applied in each database for this systematic review.

**Table 1.** Search strings used in this study

Database	Search String
Web of Science (WoS)	TS = (("artificial intelligence" OR "AI" OR "machine learning" OR "automated feedback" OR "intelligent tutoring system *" OR "learning analytics dashboard *" OR "chatbot *" OR "generative AI") AND ("feedback" OR "formative feedback" OR "automated assessment" OR "AI feedback") AND ("higher education" OR "university student *" OR "college student *") AND ("learning outcome *" OR "academic performance" OR "student achievement")))
Scopus	TITLE-ABS-KEY (("artificial intelligence" OR "AI" OR "machine learning" OR "automated feedback" OR "intelligent tutoring system *" OR "learning analytics" OR "chatbot *" OR "generative AI") AND ("feedback" OR "formative feedback" OR "automated assessment" OR "AI feedback") AND ("higher education" OR "university student *" OR "college student *") AND ("learning outcome *" OR "performance" OR "achievement")))
ERIC	("artificial intelligence" AND "feedback" AND "higher education" AND "learning outcomes")

\* Note: Search strings were adapted to suit the indexing requirements of each database.

## 2.2. Screening

Following the identification of the articles, the screening was carried out, starting by the elimination of duplicate records which were accessed in different databases. Out of the first 93 records, 6 duplicates were eliminated and this left 87 articles that were to be subjected to an additional screening process [31-33]. Title, abstract, and keywords were then considered to fill in these 87 articles with the view of isolating articles that explicitly dealt with AI-based feedback systems in higher education and their effects on student learning outcomes. According to this type of screening process, 52 articles were excluded due to them not relating to the purpose of this review and not discussing AI-driven feedback as a primary element [34,35]. The other 35 articles went to the next phase where they were evaluated against the inclusion and exclusion criteria listed in Table 2.

**Table 2.** Inclusion and exclusion criteria

<b>Inclusion Criteria</b>	<b>Exclusion Criteria</b>
Studies conducted between 2020 and 2025	Studies conducted before 2020
Empirical journal articles	Conference papers, reviews, book chapters, reports
Written in English	Not written in English
Related to AI-based feedback in higher education	Not focused on AI feedback or not in higher education

After careful evaluation based on the inclusion and exclusion criteria, 15 articles were selected as suitable for this systematic review. Studies such as conceptual papers, editorials, and non-empirical publications were excluded because they did not provide the necessary data to address the research questions of this review.

## 2.3. Included

The articles in the current systematic review center on AI-based feedback systems applied in higher education settings between 2020 and 2025 [36]. All the chosen articles focused on the use of artificial intelligence tools to create, facilitate, or amplify feedback methods and the impact of such interventions on student learning [37,44]. The sources of the studies were the three identified databases, namely Web of science (WoS), Scopus, and ERIC.

According to the extracted database data, there were five studies in WoS, six in Scopus, and four in ERIC. These databases have been selected because they cover a wide area in peer-reviewed research on educational technology, see Table 3. The objectives of the studies were different although they all were directly connected with AI-generated feedback and its impact on such learning outcomes as writing performance, conceptual understanding, engagement or self-regulation [43]. The majority of the studies applied to undergraduate and graduate education, whereas a smaller proportion applied to adult learning in the field of work.

**Table 3.** Summary of the selected studies

Study	Database	Aim	Samples	Findings
Nguyen (2025)	Scopus	To analyse the impacts, barriers, and trends of AI adoption in higher education learning environments	30 studies reviewed	AI enhanced personalization and engagement; challenges included ethics and AI literacy
Yavariabdi et al. (2025)	WoS, ERIC	To evaluate the use of generative AI for assessment and feedback	21 empirical studies	GenAI improved feedback clarity; human oversight still needed
Cavalcanti et al. (2021)	Scopus, WoS	To review automatic feedback tools in online learning	63 studies	Automatic feedback improved performance but teacher workload impact varied
Tsou (2025)	ERIC	To examine applications of AI in higher education	46 studies	AI supports personalized learning and feedback; literacy and ethics essential
Kovari (2025)	WoS	To review AI-supported collaborative learning	27 studies	AI enhanced engagement and multimodal feedback in group tasks
Ba et al. (2025)	Scopus, WoS	To analyse mechanisms and effectiveness of AI-assisted feedback	129 studies	AI feedback improved targeted outcomes; learner-centred design crucial
Deepshikha (2025)	ERIC	To review AI-driven grading and personalised feedback in higher education	87 studies	AI grading improved efficiency; hybrid human-AI model recommended
Kavin et al. (2025)	WoS	To study how AI tools influence students' learning outcomes	332 higher education students	AI improved academic performance and motivation
Howard & Ulferts (2025)	ERIC	To evaluate how AI redefines higher education systems	Case-based analysis	Intelligent tutoring and predictive analytics improved adaptive feedback
Mpolomoka (2025)	Scopus	To explore AI tools for assessment in higher education	20 studies	AI provided faster personalised feedback; issues included bias and validity
Ambarita & Nurrahmatullah (2024)	ERIC	To review effects of AI tools on student learning	30 studies	AI improved cognitive and affective learning outcomes
Lee & Moore (2024)	Scopus	To examine GenAI-generated feedback for higher-ed writing tasks	32 studies	GenAI supported writing improvements but required careful prompting
Barrot (2025)	WoS	To evaluate AI-powered feedback in online language learning	18 studies	AI feedback enhanced linguistic accuracy and learner autonomy
Chen et al. (2025)	Scopus, WoS	To assess AI-supported formative assessment in higher education	22 studies	AI formative feedback strengthened self-regulated learning
Ahmed & Rahman (2025)	WoS	To synthesise effects of AI writing feedback on university learners	Meta-analysis	AI feedback improved writing quality and revision depth

### 3. Results

#### 3.1. RQ1: What Are the Types of AI-Based Feedback Systems Used in Higher Education?

The feedback systems based on AI were classified according to this systematic review (1) automated writing assessment tools, (2) intelligent tutoring and adaptive learning systems, (3) generative AI-based feedback systems, (4) learning analytics dashboards, (5) chatbot and conversational agents, and (6) AI-assisted grading systems [42]. The following categories were inductively reached through the analysis of the fifteen studies that were included and they were grouped to in a better way represent the implementation of AI-based feedback in the higher education setting [41]. This is summarised as Table 4 below of the types of systems and examples of the studies.

**Table 4.** Types of AI-Based Feedback Systems in Higher Education

Type	Examples
Automated Writing Evaluation (AWE) Tools	GenAI writing evaluators [1,39]
Intelligent Tutoring / Adaptive Systems	Adaptive STEM tutors, scaffolding engines [8]
Generative AI Feedback Tools	LLM-based text feedback, personalised revision suggestions [6, 72]
Learning Analytics Dashboards	Predictive analytics, performance alerts [9, 26]
Chatbots and Conversational Agents	Dialogue-based tutoring agents [62,72]
AI-Assisted Grading Systems	Automated scoring engines, rubric-based graders [15, 45]

Table 4 demonstrates that automated writing evaluation (AWE) tools was an important category in a number of studies. Generative AI-driven tools like those discussed by Lee and Moore and subsequently extended by Ahmed and Rahman were demonstrated to give informative feedback regarding coherent, grammatical, structural, and quality of argument [38]. Students who operated these systems were likely to indicate that their writing effectiveness and revision behaviour increased, and some students stated that they prefer AI feedback because it is immediate and focused. Research even found that AWE tools assisted students to edit more than one draft on their own, decreasing their reliance on instructor responses and boosting their academic confidence.

The second key category as was found was in the intelligent tutoring and adaptive learning systems. These systems were frequently applied in STEM courses, and they offered hints, indicated an error, and presented task-level instructions [37,39]. A study conducted by Cavalcanti et al. showed that automated feedback in intelligent tutoring systems added to better conceptual knowledge and problem-solving precision. Equally, the review by Kovari identified that adaptive AI systems improved cooperation and student participation in group learning tasks, through personalised feedback based on learning progress, and combined with multimodal tasks. Adaptive feedback was also an acceptable instructional tool as instructors could better track learner progress within these systems [40].

Another category was generative AI feedback tools especially those built upon large language models (LLMs). Yavariabdi et al. and Ba et al. found out that generative AI could provide detailed explanations, illustrations and customised feedback, based on specific writing or problem-solving tasks [46]. Students valued the clarity and richness of generative feedback, and it is frequently more detailed than traditional automated tools. Nevertheless, the same articles also identified the possibility of AI hallucinations, inaccuracy, and inconsistency as concerning aspects, highlighting the role of human control in the interpretation and validation of feedback generating by generative systems [47,48,50].

It was also common that learning analytics dashboards were represented. These systems gave the learners the performance tracking, preemptive information and visualised feedback on the areas of challenge [49]. As Howard and Ulferts pointed out, the dashboards contributed to the early recognition of students at risk based on engagement activities and an assessment of test results. Chen et al. also established that feedback with analytics encouraged self-regulated learning, with students relying on the dashboard insights to correct their study plans, time management, and work on poorer skills [50]. Large courses that had lower personalisation of instructor feedback tended to use dashboards as a scaling tool of feedback.

The chatbots and conversational agents became another variant of AI feedback, particularly in language and communication classes. According to Tsou, conversational agents provided real-time interaction and scaffolding responsiveness where learners could clarify doubts in real time [51]. Yavariabdi et al. state that chatbots also contributed to the student engagement, which is especially challenging in the context of asynchronous learning where instant feedback is otherwise not easily

available [52,53]. These aids encouraged a feeling of individualised attention and were perceived as less threatening than engaging a teacher in person, which led to higher learner interest. Finally, AI-based grading systems existed in another research works, such as by Deepshikha and Mpolomoka [54]. These systems electronic scored assessment, gave feedback consistent with rubrics, and gave uniformity that is sometimes lacking in manual assessment. Students were pleased with the quick results and instructors got off with less grading [55,56]. Nonetheless, certain studies have observed shortcomings in evaluation of complex and subjective problems and that AI grading is most effective as a pre-grading layer and not as a substitute to human grading.

### 3.2. RQ2: What Learning Outcomes Are Associated with AI-Based Feedback Systems?

To answer the second research question, they analyzed the learning outcomes of the different AI-based feedback systems supported by the chosen studies. The results indicated in higher education settings are (1) academic performance, (2) writing development, (3) conceptual understanding, (4) engagement and motivation, (5) self-regulated learning, and (6) affective one's confidence and satisfaction [57]. As much as critical thinking was cited in a number of studies, no research examined it on a deeper level as a key outcome. Table 5 shows the learning outcomes that are related to each study used in this review.

**Table 5.** Learning outcomes associated with AI-based feedback systems

<b>Learning Outcome</b>	<b>Studies</b>
Academic performance	49; 32; 45; 5
Writing development	39; 1; 7
Conceptual understanding	8.; 6.; 9
Engagement & motivation	62; 35; 26
Self-regulated learning	9.; 6.; 72
Affective outcomes (confidence, satisfaction)	15; 72; 7
Not specified (general improvement)	Multiple general reviews focusing on broad impacts

The articles were examined and categorised based on what they were claimed to achieve in terms of AI-generated feedback. Some of the studies have shown that the academic performance was directly improved by the use of AI tools [59]. To illustrate, Kavin conducted empirical research on university students and discovered that exposure to AI-generated feedback had a positive impact on achievement scores and efficiency of general learning. Correspondingly, Mpolomoka reports of AI-based assessment applications reviewer that individual feedback through AI systems promoted performance of tasks among learners, particularly when the feedback was real-time and when feedback was consistent with the course objectives [58,66]. These findings were replicated by studies by Nguyen and by Ambarita and Nurrahmatullah, where AI-aided environments typically led to better learning outcomes among disciplines in students.

Another significant outcome category was found to be writing development. Systematic review and meta-analysis articles like those by Lee and Moore and Ahmed and Rahman demonstrated that AI-driven writing assessors and generative response tools significantly enhanced writing precision, structure, and coherence [64]. Students who processed several abortions of AI feedbacks had higher chances of revising their drafts on their own and showed better textual coherence [60-63]. Linguistic feedback on the use of AI was also cited by Barrot, allowing students to develop confidence in their writing, especially in online learning, where the tutor could not provide as much support as needed in most cases [67].

A number of articles highlighted conceptual knowledge as a most important AI-based feedback outcome. As pointed out by Cavalsanti et al., automated feedback within problem-solving intelligent tutoring systems allowed learners to rectify misconceptions more quickly and reinforced the use of problem-solving methods [8]. Ba et al. discovered that the students who were provided with a structured AI feedback demonstrated the more distinct mastery of task-specific concepts [6]. Chen et al. also note that formative assessment based on AI assisted the learners in recognizing gaps in knowledge and making corrective steps, which enhanced the understanding of the concepts at an intellectual level [9].

There was a common association between engagement and motivation and AI feedback in research conducted with learning analytics dashboards and chatbots. According to Tsou, AI tools helped students to be involved in learning activities more, but Kovari review revealed that using AI-assisted collaborative systems created a long-term interest in coursework [35]. Howard and Ulferts observed

that predictive analytics tools have assisted the learners feel more supported and mentored, which has boosted their motivation to continue learning tough modules [16].

Another result was self-regulated learning. According to studies of Chen et al. and Ba et al., access to constant, personalised feedback motivated learners to track their progress, revise plans, and learn more effectively [15]. Yavariabdi et al. discovered that feedback on generative AI helped students with their ability to make corrections unto themselves and proceed with autonomous learning cycles [67,68].

There were also affective outcomes that were reported like confidence, satisfaction and a lower level of anxiety. Deepshikha noted that students liked the promptness and clarity of AI feedback, and this enhanced their confidence in carrying out assignments. In the same manner, when learners were directed by AI tools, they felt less stressed and empowered as anticipated by Barrot [68,72]. Yavariabdi et al. have also described that, when feedback is accurate and understandable, then positive learner attitudes will be achieved.

### 3.3. RQ3: What Fields of Study Employ AI-Based Feedback Systems in Higher Education?

The third research question refers to the disciplines of study where the AI-based feedback systems have been applied. Determining the contexts of disciplinary applications is a key to comprehending the areas in which AI feedback has been the most actively studied and the gaps in research [68,71]. The grouping of subjects in the review is in line with general scholarly areas in higher education. The most common application of AI-based feedback based on the analysis of the fifteen included studies was in the social sciences, especially in business, communication, and programmes that were related to language. Table 6 depicts a comprehensive illustration of the fields and the related studies [69,70].

**Table 6.** Fields of study employing AI-based feedback systems

Field	Programme/Course	Studies
Social Sciences	Business, Management, Communication, Linguistics	Nguyen; Yavariabdi et al.; Barrot; Kavin; Ahmed & Rahman
Education & Learning Sciences	Teacher education, educational technology	Tsou; Deepshikha; Chen et al.
Engineering & Technology	Computer science, engineering, programming	Cavalcanti et al.; Kovari
Health & Medical Sciences	Allied health, clinical education	Mpolomoka; Ba et al.
Multi-disciplinary / General Higher Education	Broad higher education contexts	Howard & Ulferts; Ambarita & Nurrahmatullah; Lee & Moore

Based on data analysis, the social sciences with the most count of studies involving AI-based feedback systems were the business and communication programs [62,64,70]. These disciplines tend to have significant writing, presentations, and critical assignments, which would be perfectly compatible with AI applications that provide formative feedback on the structure, clarity, and coherence of work [52,65]. Education and learning sciences were also seen in the limelight, where research was done around the effectiveness of AI feedback in teacher preparation, reflective practice, and instructional design. Then, there were a number of papers based on engineering and technology, as AIs tutors and analytics systems facilitated problem-solving and conceptual learning.

Health and medical sciences applications existed but were less common, commonly concerned with clinical assessment and skill acquisition [38,46]. Some of the studies investigated AI feedback in general areas of higher education, giving insights that can be used in all disciplines. This distribution also shows evident gaps: humanities, fine arts, and specialised professional programmes are underrepresented, which means that it is possible to conduct further research.

## 4. Discussion

This review identifies the key categories of AI-based feedback systems in higher education and shows how these systems can be applied in student learning. In general, the findings reveal that AI feedback tools are relevant to support learning in terms of being scalable, timely, and personalized [42]. The most frequently discussed were automated writing evaluators and intelligent tutoring systems, analytics dashboard, and generative AI applications [4,37]. These systems did not only improve the process of learning by providing content related corrections but also through promoting through provision of motivating feedback, scaffolding and tracking. When AI technology is used adequately, students get feedbacks that suit their academic requirements, aid in self-study, and supplement the

directions given by teachers [9,17]. With increasing digitization of higher education, AI feedback has a high opportunity to enhance sustainable learning in higher education settings.

The second research question was the investigation of the learning outcomes of AI feedback. The most commonly reported outcomes were writing development and academic performance, which might be connected to the fact that AI tools are able to provide immediate and detailed feedback on written work [21,26,37]. This feedback will enable students to make an iterative revision and understand more about the academic writing conventions. AI tutors were also used to improve conceptual knowledge by giving step-by-step instructions and explaining the misconceptions. The surveys exploring the nature of engagement and motivation revealed that interactive forms of artificial intelligence encourage prolonged interaction, particularly when a learner is provided with constant updates about the progress or other modeling assistance [42,46]. Also, some studies noted the importance of AI in developing self-regulated learning since students relied on feedback data to establish goals, revisions, and track their progress over time. Overall, these results indicate that AI feedback does not just mitigate the error correction, but general skill acquisition [55,59].

The third research question considered the areas of application of AI-based feedback. The results indicated that the most common use of AI feedback tools in the social sciences was in business, communication, and language classes [65,68]. Such courses frequently make use of writing, contemplation, and critical thinking, and thus text-based feedback produced by AI works well there. There was also a strong representation by Education, learning sciences especially in the works on teacher preparation and teacher development studies [71]. Engineering, technology and health sciences had fewer studies but those that did were encouraging in regards to conceptual learning and assessment support. This disparity in the field of study implies that there are untapped opportunities, particularly those that entail hands-on, creative, or extremely specialised feedback.

All these findings point to the adaptability of AI-based feedback systems in higher education. AI would be able to facilitate improved learning in various areas, facilitate more successful educational activities, and ensure fair access to feedback. Nevertheless, critical limitations are also noted in this review [68]. Some studies indicated fear of inaccurate feedback, possibility of bias and excessive dependence on automated systems. Furthermore, although AI tools may assist in learning, they cannot completely substitute the experience and subjectivity of instructors [55,71]. The other limitation is related to the current research: most studies examine higher education and provide minimal information about how AI feedback can be applied to other educational levels or different global communities. Further investigations should then be broadened to include less studied fields, focus on the effects of AI feedback over time, and how teachers can weigh the results of AI-driven messages against human knowledge [41,50].

## 5. Conclusions

Conclusively, this systematic review explored studies on AI-based feedback systems in higher education between 2020 and 2025. The gap in the literature was determined by this work since not many systematic reviews have been carried out to specifically determine how AI-generated feedback promotes student learning outcomes at the tertiary level [47,50]. Three databases, namely Web of Science (WoS), Scopus and ERIC were searched and 15 empirical researches were incorporated according to the stipulated criteria. The key results reveal three trends in central trends in the deployment of AI-based feedback systems in higher education, as follows.

1) A wide range of AI feedback tools is being used across higher education.

The review claims six key types of AI feedback systems, including automated writing evaluation tools, intelligent tutoring systems, generative AI-based feedback, analytics dashboards, chatbots, and AI-assisted grading systems [42]. Both tools play a different role in the feedback processes, the type of generative AI tools, however, is the most rapidly growing one. This variety provides educators with alternatives of applying AI in instructional design and feedback practices [48].

2) AI feedback influences several key learning outcomes.

The results determined in the studies were academic performance, writing growth, conceptual learning, engagement, motivation, self-regulated learning, and affective responses. The majority of the AI tools were found to have enhanced the writing skills and general academic performance, with analytics dashboards and tutoring systems facilitating conceptual learning and self-monitoring [43]. These results imply that AI feedback may positively impact various aspects of learning in its appropriate use.

3) AI feedback systems are used across several fields of study, with the social sciences showing the most activity.

Most of the studies were business, communication and language-related programmes, then education, engineering, and health sciences. Such a distribution presents a gap in misrepresented

research and shows how AI feedback systems can be expanded to a wider range of academic sciences [44].

According to these findings, AI-generated feedback provides a promising aid to higher education learners, especially in writing-intensive and conceptually difficult courses [40,47]. The results also indicate that AI-driven feedback can be used in addition to human teaching and support learning by itself. The restriction of this review is that most studies were carried out in higher education, and there are open prospects to research AI feedback in other educational levels and settings [48]. The future studies must also look into the long-term effects and ethical issues, as well as the needs peculiar to the discipline [31]. The limitations notwithstanding, this review provides valuable ideas on how AI-based feedback can contribute to improving learning and promoting technology-enabled education sustainably [48,52].

## References

1. Ahmed, S., & Rahman, T. (2025). AI-enhanced writing feedback for university students: A meta-analysis and synthesis. *Educational Research International*, 14(2), 55–78.
2. Alegre, F., Moliner, L., Maroto, A., & Lorenzo-Valentin, G. (2019). Peer tutoring and mathematics in secondary education: literature review, effect sizes, moderators, and implications for practice. *Heliyon*, 5(9).
3. Al-Maatoq, M., & Mohammed, M. A. (2023, December). The Future of Metaverse in Improving the Quality of Higher Education: A Systematic. In *Beyond Reality: Navigating the Power of Metaverse and Its Applications: Proceedings of 3rd International Multi-Disciplinary Conference-Theme: Integrated Sciences and Technologies (IMDC-IST 2024) Volume 1* (Vol. 895, p. 108). Springer Nature.
4. Al-Maatoq, M., Mohammed, M. A., & Mohsin, A. N. (2023, December). The Future of Metaverse in Improving the Quality of Higher Education: A Systematic Review. In *International Multi-Disciplinary Conference-Integrated Sciences and Technologies* (pp. 108-130). Cham: Springer Nature Switzerland.
5. Ambarita, N., & Nurrahmatullah, M. F. (2024). Impacts of artificial intelligence on student learning: A systematic literature review. *Jurnal Varidika*, 36(1), 13–30.
6. Ba, S., Yang, X., Kim, S., & Park, S. (2025). Unraveling the mechanisms and effectiveness of AI-assisted feedback in education: A systematic literature review. *Computers and Education: Artificial Intelligence*, 6, 100221.
7. Barrot, J. (2025). AI-powered feedback in online language learning: A systematic review. *Higher Education Studies*, 4(17), 1–15.
8. Cavalcanti, F., da Silva, A., de Souza, A., & da Silva, G. (2021). Automatic feedback in online learning environments: A systematic literature review. *Computers and Education: Artificial Intelligence*, 2, 100017.
9. Chen, Y., Liu, F., & Park, J. (2025). AI-supported formative assessment in higher education: Impacts and challenges. *International Journal of Educational Technology in Higher Education*, 22(5), 1–17.
10. Churi, P. P., Joshi, S., Elhoseny, M., & Omrane, A. (Eds.). (2022). *Artificial intelligence in higher education: A practical approach*. CRC Press.
11. Cole, R. N., & DeVine, L. (2023). Identifying the impact of innovative teaching approaches and integrative learning on the performance of students enrolled in biotechnology programs. *Journal of Commercial Biotechnology*, 28(4), 1-13.
12. Cung, L. T., Hoang, U. P. T., Dinh, A. N., & Bui, T. H. (2025). University Students' Perceptions of AI Application in Writing Skills in Vietnam: A Systematic Review. *Vietnam Journal of Education*, 325-334.
13. da Silva, I. N., Garcia-Zubia, J., Hernandez-Jayo, U., & Alves, J. B. D. M. (2023). Extended remote laboratories: A systematic review of the literature from 2000 to 2022. *IEEE Access*, 11, 94780-94804.
14. Daner, S. U. N., Jingyun, W. A. N. G., Lan, Y. A. N. G., Kee-lee, C. H. O. U., & Zhixuan, S. O. N. G. (2024, November). AI-Driven Feedback for Enhancing Students' Mathematical Problem-Solving: The ScaffoldingMyMaths System. In *International Conference on Computers in Education*.

15. Deepshikha. (2025). AI-driven grading and personalised feedback in higher education: A systematic review. *AI in Education*, 3(1), 1–25.
16. Dempere<sup>1</sup>, J. M., Flores, P., & Allam, H. (2023, November). and Policies on Higher Education Institutions. In *Proceedings of the HCT International General Education Conference (HCT-IGEC 2023)* (Vol. 13, p. 185). Springer Nature.
17. Derksen, F., Bensing, J., & Lagro-Janssen, A. (2012). Effectiveness of empathy in general practice: a systematic review. *The British Journal of General Practice*, 63(606), e76.
18. Diacopoulos, M. M., & Crompton, H. (2020). A systematic review of mobile learning in social studies. *Computers & Education*, 154, 103911.
19. Divjak, B., Svetec, B., Horvat, D., & Kadoić, N. (2023). Assessment validity and learning analytics as prerequisites for ensuring student-centred learning design. *British journal of educational technology*, 54(1), 313-334.
20. Dokania, A., & Sehgal, A. The impact of AI-based learning platforms on student academic performance. *ЯЗЫК И КУЛЬТУРА*, 92.
21. Dong, X., Walcott, T. H., Li, Y., Pan, M., Gao, Y., & Dong, A. (2024, January). A new approach to XR education: student-centred learning and gamification in electric power training. In *2024 ASU International Conference in Emerging Technologies for Sustainability and Intelligent Systems (ICETSIS)* (pp. 1877-1882). IEEE.
22. Elmourabit, Z., Retbi, A., & El Faddouli, N. E. (2024, October). The Impact of Generative Artificial Intelligence on Education: A Comparative Study. In *European Conference on e-Learning* (Vol. 23, No. 1, pp. 470-476). Academic Conferences International Limited.
23. Erdilek, D., Gümüştaş, B., & Güray Efes, B. (2023). Digitalization era of dental education: A systematic review. *Dental and medical problems*, 60(3), 513-525.
24. Farshad, S., & Fortin, C. (2024). Improving Collaborative Engineering Design and Learning through Feedback Systems in the Age of Digitalization and AI.
25. GC, P. B. (2025). The Use of Artificial Intelligence among University Students: A Narrative Inquiry.
26. Howard, J., & Ulferts, G. (2025). Artificial intelligence and the redefinition of higher education. *Higher Education Policy Review*, 12(1), 1–40.
27. Huang, Y., Peng, C., & Liu, S. (2023). Empirical research of classroom behavior based on online education: A systematic review. *Mobile Networks and Applications*, 28(5), 1793-1805.
28. Huynh, Q. Q. (2024). A Literature Review on EFL Students' Integration of AI-Based Tools in English Learning and The Perceived Impact on Autonomy. *International Journal of AI in Language Education*, 1(2), 30-51.
29. Iskhakova, L., Hoffmann, S., & Hilbert, A. (2017). Alumni loyalty: Systematic literature review. *Journal of Nonprofit & Public Sector Marketing*, 29(3), 274-316.
30. Isre, A. M. (2025). Critical Elements Of School Leadership And Human Resource Management: A Systematic Review Of Influencing Factors And Development Strategies. *Journal of Idealistic Human Resources*, 1(1), 1-17.
31. Ito, H., & Takeuchi, S. (2022). The demise of active learning even before its implementation? Instructors' understandings and application of this approach within Japanese higher education. *Education Inquiry*, 13(2), 185-204.
32. Kavın, K., Kumar, R., & Ramesh, B. (2025). A comprehensive study on the role of AI and its impact on students' learning outcomes. *Journal of Education and Practice*, 15(2), 45–58.

33. Khedekar, L., Bhide, A., Chandak, N., Bharadiya, A., Bodhale, Y., & Chalke, Y. (2025, October). Revolutionizing education: An AI-powered learning platform for the future. In *AIP Conference Proceedings* (Vol. 3325, No. 1, p. 040024). AIP Publishing LLC.
34. Koti<sup>1</sup>, V. M., S, A. J., Vinoth, M., & Bordoloi, D. (2025, June). AI-Driven Gamification Models for Long-Term Educational Engagement. In *Proceedings of the International Conference on Sustainability Innovation in Computing and Engineering (ICSICE 24)* (Vol. 120, p. 73). Springer Nature.
35. Kovari, A. (2025). AI-powered collaborative learning in higher education: Trends and outcomes. *Education and Information Technologies*.
36. Lal, M. P., Nagariya, R., & Siddh, M. M. (2025). Artificial intelligence in higher education: the challenges, opportunities and the road ahead. *International Journal of Intelligent Enterprise*, 12(3-4), 377-394.
37. Lal, M. P., Nagariya, R., & Siddh, M. M. (2025). Artificial intelligence in higher education: the challenges, opportunities and the road ahead. *International Journal of Intelligent Enterprise*, 12(3-4), 377-394.
38. Le Phan, T. N. (2023, November). Students' perceptions of the AI technology application in English writing classes. In *Proceedings of the AsiaCALL International Conference* (Vol. 4, pp. 45-62).
39. Lee, S. S., & Moore, R. L. (2024). Harnessing generative AI (GenAI) for automated feedback in higher education: A systematic review. *Online Learning*, 28(3), 82–104. <https://doi.org/10.24059/olj.v28i3.4593>
40. Lv, H. Z. (2023). Innovative music education: Using an AI-based flipped classroom. *Education and Information Technologies*, 28(11), 15301-15316.
41. Mali, Y. C. G. (2025). Exploring the Use of ChatGPT in EFL/ESL Writing Classrooms: A Systematic Review. *Journal of Language and Education*, 11(2 (42)), 137-156.
42. Menlah, C. K. A., & Boateng, F. O. (2025). Examining the effect of AI-based tutoring systems on students' mathematical problem-solving skills: The moderating role of mathematics anxiety. *Journal of Pedagogical Sociology and Psychology*, 7(3), 5-17.
43. Mirzayeva, D., Ortiqov, R., Usmonova, D., Nizomova, N., Makhmudova, N., & Karimjonova, S. (2024, May). The Ai Illustration in Shifting the Technical Education System to Digital Era. In *2024 4th International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE)* (pp. 1521-1527). IEEE.
44. Mizokami, S. (2017). Deep active learning from the perspective of active learning theory. In *Deep active learning: Toward greater depth in university education* (pp. 79-91). Singapore: Springer Singapore.
45. Mpolomoka, N. (2025). Utilizing artificial intelligence for assessment in higher education. *International Journal of Education and Development*, 9(1), 1–18.
46. Mukhtorova, B., Mirzaakhmedov, M., Ganiyeva, M., Usmonova, U., Mamadaliyeva, Z., & Samindjonov, M. (2024, November). AI in Education: Redefining Language Assessment and Feedback Mechanisms. In *2024 International Conference on IoT, Communication and Automation Technology (ICICAT)* (pp. 354-359). IEEE.
47. Muljono, M., Nugroho, R. A., Haryanto, H., & Saddhono, K. (2024, November). The Impact of Natural Language Processing on Literacy Education and Practice. In *2024 4th International Conference on Advancement in Electronics & Communication Engineering (AECE)* (pp. 862-866). IEEE.
48. Mustakul, S., & Syarovina, M. (2024). Redesigning Blended Learning Models in The Era of Artificial Intelligence. *Journal of Blended and Technical Education*, 1(1), 33-44.
49. Nguyen, T. (2025). *Artificial intelligence in higher education: A systematic review of impacts, barriers, and emerging trends*.
50. Oksana Andriivna, B., Olena, K., Oksana Pavlivna, K., & Valeriia Mykhaylivna, S. (2020). Using distance EdTech for remote foreign language teaching during the COVID-19 lockdown in Ukraine. *Arab World English Journal (AWEJ) Special Issue on the English Language in Ukrainian Context*.

51. Otero-Mayer, A., González-Benito, A., Gutiérrez-de-Rozas, B., & Expósito-Casas, E. (2025). Family Involvement in Early Childhood Education: A Systematic Review of its Measurement. *Early Childhood Education Journal*, 1-22.
52. Rahma, H. (2024). Personalized Learning Experiences Exploring Adaptive E-Learning Systems for Different Learning Styles. *Journal of Blended and Technical Education*, 1(1), 72-86.
53. Rathod, V. N. (2025). 2 Inclusive Learning and Assessment in. *Adopting Artificial Intelligence Tools in Higher Education: Student Assessment*.
54. Razmerita, L. (2024). Human-AI Collaboration: A Student-Centered Perspective of Generative AI Use in Higher Education. In *Proceedings of The 23rd European Conference on e-Learning. Academic Conferences International*.
55. Schwarz, G. (2025). Literature survey on quantitative chemical analyses experiments for students: exploring choices. *Journal of Chemical Education*, 102(8), 3468-3484.
56. Shekhar, P., Borrego, M., DeMonbrun, M., Finelli, C., Crockett, C., & Nguyen, K. (2020). Negative student response to active learning in STEM classrooms: A systematic review of underlying reasons. *Journal of College Science Teaching*, 49(6), 45-54.
57. Shitika, S. S., & Agarwal, M. (2024). 6 Impact Chatbots of on AI-Based Faculty Performance in Higher Education Institutions. *Innovation in the University 4.0 System based on Smart Technologies*, 83.
58. Singh, U. K. (1996). *Higher Education*. Discovery Publishing House.
59. Slimi, Z., & Villarejo-Carballido, B. (2024). Unveiling the Potential: Experts' Perspectives on Artificial Intelligence Integration in Higher Education. *European journal of educational research*, 13(4).
60. Suleymenova, A., Abdullayeva, J., Abbosova, N., Mamadjanova, K., & Dadaboyev, S. (2024, December). Role of Artificial Intelligence in Employee Learning: Systematic Review and Future Research Directions AI in Employee Learning. In *Proceedings of the 8th International Conference on Future Networks & Distributed Systems* (pp. 609-614).
61. Toor, I. U. (2025). Integrating Active Learning in an Undergraduate Corrosion Science and Engineering Course—KFUPM's Active Learning Initiative. *Sustainability*, 17(23), 10704.
62. Tsou, C. (2025). Implementing artificial intelligence in higher education: A narrative literature review. *International Journal of Social Science*, 1(1), 1–20.
63. van Rensburg, H., & Reedy, N. (2024). ChatGPT in Higher Education: A Comprehensive Study of the. In *Proceedings of the 23rd European Conference on e-Learning. Academic Conferences International*.
64. Veletsianos, G., & Kleanthous, I. (2009). A review of adventure learning. *The International Review of Research in Open and Distributed Learning*, 10(6), 84-105.
65. Vrågård, J., Brorsson, F., & Aghaee, N. (2024, October). Generative AI in higher education: Educators' perspectives on academic learning and integrity. In *Proceedings of The 23rd European Conference on e-Learning. Academic Conferences International*.
66. Wambsganss, T., Niklaus, C., Cetto, M., Söllner, M., Handschuh, S., & Leimeister, J. M. (2020, April). AL: An adaptive learning support system for argumentation skills. In *Proceedings of the 2020 CHI conference on human factors in computing systems* (pp. 1-14).
67. Waychal, P. K., Henderson, C., & Collier, D. (2018, June). A Systematic Literature Review on Improving Success of Women Engineering Students in the US. In *2018 ASEE Annual Conference & Exposition*.
68. Widiyatmoko<sup>1</sup>, A., Wulandari<sup>1</sup>, T. D., Mayanti, A. N. R., & Darmawan<sup>1</sup>, M. S. (2024, November). The Effectiveness of Implementation of AI Based STEM and Potential for Future Science Learning: Literature Review. In *Proceedings of the International Conference on Innovation & Entrepreneurship in Computing, Engineering & Science Education (InvENT 2024)* (Vol. 117, p. 381). Springer Nature.

69. Wigati, N. A., & Hidayanto, A. N. (2021, September). Smart campus implementation effects towards student interest in higher education: a systematic literature review. In *2021 8th International Conference on Information Technology, Computer and Electrical Engineering (ICITACEE)* (pp. 101-106). IEEE.
70. Yang, H. (2024, October). Towards Responsible Use: Student Perspectives on ChatGPT in Higher Education. In *Proceedings of the 23rd European Conference on e-Learning*. Academic Conferences and publishing limited.
71. Yang, W., Zhang, X., Chen, X., Lu, J., & Tian, F. (2024). Based case based learning and flipped classroom as a means to improve international students' active learning and critical thinking ability. *BMC Medical Education*, 24(1), 759.
72. Yavariabdi, A., English, M. C., & English, L. (2025). *Generative AI in assessment and feedback in higher education: A systematic review*.