



Cultivating independent thinkers: The triad of artificial intelligence, Bloom's taxonomy and critical thinking in assessment pedagogy

Anitia Lubbe¹ · Elma Marais² · Donnavan Kruger¹

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Abstract

Amalgamating generative artificial intelligence (Gen AI), Bloom's taxonomy and critical thinking present a promising avenue to revolutionize assessment pedagogy and foster higher-order cognitive skills needed for learning autonomy in the domain of self-directed learning. Gen AI, a subset of artificial intelligence (AI), has emerged as a frontrunner in creative tasks, revolutionizing various domains such as art, music, writing and design and showcasing its ability to generate original content across various domains, including education. Incorporating social, cultural, economic and pedagogical dimensions, AI in education encompasses the incorporation of AI technologies like intelligent tutoring systems, chatbots, robots, learning analytics dashboards, adaptive learning systems and automated assessment to bolster and elevate the educational process. The significance of the impact on the creativity component of Krathwohl's revised Bloom's taxonomy arises from the utilization of Gen AI in creative tasks, which prompts concerns regarding the authenticity and originality of AI-generated content. This conceptual research study seeks to investigate the affordances of this amalgamation and aims to reframe the higher cognitive levels of Bloom's taxonomy to enhance critical thinking and self-directed learning among students. This study grounds the reader in the existing literature and sets a course for where research in this field should be heading, thus adding value, rather than only providing an overview of the literature. The overall aim of this research was to explore the affordances of the amalgamation of AI, Bloom's taxonomy and critical thinking to support assessment pedagogy for self-directed learning. This paper identifies the gap in the current literature about reconceptualizing assessment pedagogy for developing higher-order thinking skills in a Gen AI higher education landscape. This paper presents a case of revisiting Bloom's taxonomy, advocating the importance of AI fluency and assessment literacy for the development of critical thinking skills and self-directed learning.

Extended author information available on the last page of the article

Keywords Self-directed learning · Artificial intelligence · Generative artificial intelligence (Gen AI) · Bloom's taxonomy · Critical thinking · Assessment pedagogy

1 Introduction

Generative artificial intelligence (Gen AI), a subset of AI, has emerged as a front-runner in creative tasks, revolutionizing various domains such as art, music, writing and design and showcasing its ability to generate original content across various domains (Epstein & Hertzman, 2023), including education (Adiguzel, Kaya & Cansu, 2023). AI in education includes the use of AI technologies such as chatbots, robots, learning analytics dashboards, intelligent tutoring systems, adaptive learning systems, and automated assessment to support and improve the educational process. These technologies incorporate social, cultural, economic, and pedagogical dimensions (Adiguzel et al., 2023; Chen et al., 2020; Selwyn, 2016). Gen AI impacts the creativity component of Krathwohl's revised Bloom's taxonomy by excelling in creative tasks, raising concerns about the authenticity and originality of AI-generated content (Michel-Villarreal et al., 2023).

While existing studies explore the use of Gen AI in education and its alignment with Bloom's taxonomy, a critical gap remains in understanding how these tools can specifically enhance higher-order cognitive skills, such as evaluation and creation, to advance assessment pedagogy for self-directed learning (SDL). This study addresses this underexplored intersection to provide actionable insights for fostering critical thinking in artificial intelligence (AI)-driven education. This conceptual research study seeks to investigate the affordances of this amalgamation. It aims to reframe the higher cognitive levels of Bloom's taxonomy to enhance critical thinking and self-directed learning among students. This research aimed to explore the affordances of the amalgamation of AI, Bloom's taxonomy and critical thinking to support assessment pedagogy for self-directed learning.

The conceptual and theoretical frameworks are the fundamental concepts of AI, Bloom's taxonomy, critical thinking, assessment pedagogy and self-directed learning grounded in social constructivism. This theoretical perspective emphasizes the social nature of learning, acknowledging that knowledge construction is a collaborative and interactive process shaped by cultural contexts and social interactions (Vygotsky, 1978).

Social constructivism posits that knowledge is co-constructed through social interactions, dialogue, and engagement with cultural tools and environments (Rannikmäe et al., 2020; Vygotsky, 1978). This perspective is particularly relevant to the proposed integration of Gen AI, Bloom's taxonomy, and critical thinking, as these elements serve as modern cultural tools that facilitate collaborative and interactive learning. The framework leverages Gen AI as a mediating artefact in self-directed learning, enabling students to interact with AI-generated content, evaluate its reliability, and refine their understanding through iterative feedback loops. By grounding this study in social constructivism, we underscore the importance of active engagement, peer interaction, and reflective dialogue in fostering critical thinking and self-directed learning. This theoretical lens also informs our methodology by emphasizing the iterative analysis of AI tools in relation to Bloom's

taxonomy and higher-order thinking skills. Learning is not simply absorbing information but a dynamic process of making meaning and sense-building through collaborative activities, dialogue and reflection.

2 Theoretical background

2.1 Artificial intelligence

The history of AI development traces back to antiquity, with myths and literature written about artificial beings with intelligence. However, the modern field of AI began to take shape in the mid-twentieth century with significant milestones, as illustrated in Fig. 1.

The significant developments in AI can be laid out as follows:

The groundwork dates to the pre-1950s when Ada Lovelace proposed the idea of machines manipulating symbols (Hollings, Martin & Rice, 2018). Alan Turing introduced the concept of a universal machine, the Turing Machine (Muggleton, 2014), and Warren McCulloch and Walter Pitts developed the first mathematical model of a neural network (Yaqub, 2018). The term "artificial intelligence" was coined at the Dartmouth Conference in 1956, where pioneers like John McCarthy and Marvin Minsky laid the foundation for AI research (McCarthy et al., 2006). Notable developments include the invention of the perceptron, Lisp programming language and self-learning programs like Arthur Samuel’s checkers program. The 1970 to 1980 period saw the rise of expert systems and neural networks, marked by reduced funding during the "AI Winter." Noteworthy advancements include Den-dral (an expert system) and the reintroduction of the backpropagation algorithm (Lindsay et al., 1993).

The internet era from 1990 to 2000 fueled machine learning advancements, with milestones like IBM’s Deep Blue defeating Garry Kasparov in chess and Sony releasing AIBO, a robotic pet (De Cremer & Kasparov, 2021). IBM’s Watson winning Jeopardy! in 2011 (Ferrucci et al., 2013) and Google’s AlphaGo beat-

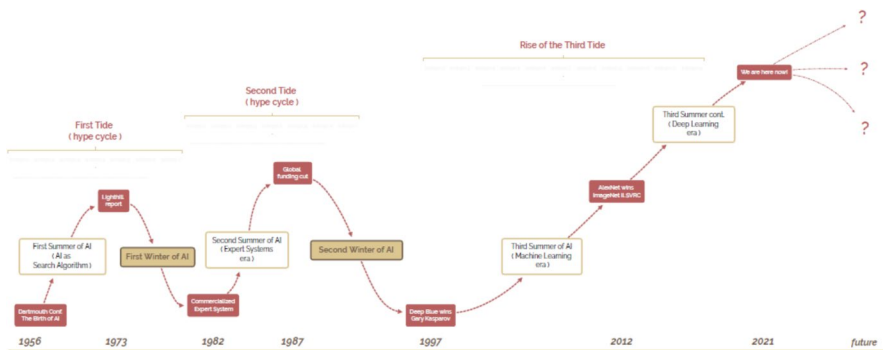


Fig. 1 The history of AI (Toosi et al., 2021)

ing Lee Sedol in “Go” in 2016 (Koch, 2016) were significant achievements. While the first Generative Pre-trained Transformer GPT was released in 2018, the most significant release came in November 2021 when ChatGPT, using GTP-3, became available to the general user (Wu et al., 2023). The 2020s witnessed a resurgence in AI interest with the successful application of machine learning to various domains. GPT-3 revolutionized natural language by putting Gen AI in the hands of a much larger group of people than ever before. Overall, AI has evolved from theoretical foundations to practical implementations, transitioning through periods of excitement, setbacks (AI winters), and resurgence driven by technological advancements and innovative applications.

Artificial intelligence (AI) is significantly impacting higher education assessment by challenging traditional evaluation methods and demanding that higher education educators re-evaluate their approach to teaching and assessment (Rudolph et al., 2023; Sullivan, Kelly & McLaughlin, 2023).

2.2 Background to Gen AI in higher education

The development of AI in the educational sphere shows a slow yet significant fusion of technological advancements with pedagogical methodologies (Donga, 2024; Haider, 2023). Initially, the role of AI within the academic domain was relegated to streamlining administrative operations and easing the digestion of complex datasets (Holmes et al., 2019). With technological progress, AI’s involvement escalated towards facilitating customized education approaches and adaptive instruction platforms, aiming to address the requirements of students (Holmes et al., 2019). Intelligent tutoring systems around the mid-2000s marked a new phase where these systems could mimic individualized human mentorship through student feedback and assistance (Lin, Huang & Lu, 2023). These developments laid the groundwork for today’s landscape featuring Gen AI within the higher education setting, where AI has rapidly gained traction in higher education, offering a range of applications for teaching, learning, assessment, and research purposes (Baytas & Ruediger, 2024).

The rise of Gen AI within higher education has ignited both enthusiasm and apprehension amongst scholars and specialists in this sector (Hodges & Ocak, 2023). Generative AI has become part of tertiary education and a key aspect of pedagogical activities and considerations. Generative AI refers to large language models that can generate new information instead of only analyzing existing literature (Baidoo-Anu & Ansah, 2023; Hodges & Ocak, 2023). Generative AI can generate human-like responses to questions. This can include written text, graphic and audio responses from trained data (Brynjolfsson, Li & Raymond, 2023; Feuerriegel et al., 2024). Examples of Gen AI include ChatGPT, Copilot, Gemini, Bart, Deepseek, and Dall-E, to name but a few. Generative AI has started and will continue transforming higher education concerning instructional methodologies and assessment (Hodges & Ocak, 2023; Parra & Chatterjee, 2024).

In higher education, the growth of Gen AI applications has introduced teaching and learning but also raised concerns about how assessment looks within the

higher education environment (Smolansky, Cram, Radulescu & Zeivots, 2023). The development of Gen AI in higher education has transitioned from being a supportive tool for teaching and learning to a disruptive force that advocates for re-evaluating pedagogical and assessment practices. Gen AI requires educators to reconsider how students engage with information and how critical thinking is facilitated in an AI environment (Carvalho et al., 2022). Despite concerns about students potentially misusing Gen AI for cheating, the focus is shifting towards recognizing the vast opportunities these tools bring to learning environments. Institutions are encouraged to engage in discussions about Gen AI literacy to ensure that students and faculty understand how to critically engage with these technologies while upholding academic integrity and ethical standards (Reiss, 2021).

In essence, the background of Gen AI in higher education showcases a transformative potential that aims to optimize learning experiences, promote equity in education access and revolutionize traditional teaching methods through personalized and adaptive approaches facilitated by AI technologies (Reiss, 2021; Vincent-Lancrin & Van der Vlies, 2020).

While Gen AI can be utilized as a tool to create content and adapt to an individual student's learning, it raises concerns about students' academic integrity and in-depth knowledge on a specific topic (De Carvalho, 2023). It challenges our traditional view of learning and the traditional hierarchy of assessment in accordance with Bloom's taxonomy.

The evolution of artificial intelligence, from its theoretical origins to its current applications in diverse fields, highlights its transformative potential in reshaping human interactions with technology. In higher education, AI has progressed from streamlining administrative tasks to becoming a disruptive force, requiring a fundamental rethinking of teaching and assessment practices. Generative AI, with its ability to produce human-like content, presents both opportunities and challenges for educators, particularly in fostering critical thinking and self-directed learning. This transition calls for the strategic integration of AI technologies with pedagogical frameworks, such as Bloom's taxonomy, to prepare students for an AI-driven future.

2.3 Bloom's taxonomy, critical thinking and self-directed learning

Bloom's taxonomy, originally introduced in 1956, classified cognitive skills hierarchically into six levels: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation (Bloom, 1956; Forehand, 2010). In the 2002 revision by Krathwohl (2002), significant changes were made to reflect modern pedagogical needs. The revised taxonomy uses action-oriented verbs (e.g., Remembering, Understanding, Applying) and shifts 'Creating' to the highest cognitive level, replacing 'Synthesis' and positioning it above 'Evaluating.' This restructuring emphasises innovation and originality as key educational goals, which are highly relevant in the context of Gen AI. Generative AI tools such as ChatGPT align well with this revision, as they facilitate tasks at higher-order levels like Creating and Evaluating. However, the integration of Gen AI into assessment practices requires a deeper exploration of how these categories can scaffold critical thinking and support students' navigation of Bloom's

revised hierarchy. Educators can use Bloom's taxonomy to create learning objectives, curricula, and assessments that gradually focus on higher-order thinking skills to help students develop deeper comprehension and critical thinking skills. (Elsayed, 2023). These days, all educational settings use Gen AI tools (like the ChatGPT chatbot) to create, design, innovate, compose, plan, formulate, generate, theorize, produce, develop, originate, arrange, and construct with a high degree of accuracy (Sinha et al., 2023), therefore, isn't it time to revisit Bloom's taxonomy once more to make sure that critical thinking and evaluation become part of any interaction with AI-generated content?

Critical thinking is "an individual thought process that begins with the intent to solve a problem or answer a question by examining different options and choosing the most suitable and logical one" (Alsaleh, 2020, p. 21). It is the ability to analyze, synthesize and evaluate information or ideas to form well-reasoned judgments or decisions (Facione, 1990; Garrison, 1997). Critical thinking is essential for self-directed learning development as it empowers students to think independently, critically assess information and develop intellectual autonomy.

Self-directed learning is a process through which individuals take responsibility for their learning journey. Self-directed learners actively set learning goals, identify resources, and devise strategies to achieve their objectives (Knowles, 1975). Such learning promotes autonomy, metacognition, and intrinsic motivation, empowering students to become independent and lifelong learners capable of adapting to changing environments and acquiring knowledge beyond formal education. Within a self-directed assessment approach, assessment pedagogy encompasses a range of assessment methods, tools, and strategies that are used pedagogically to promote student learning. In the context of self-directed learning, assessment pedagogy is crucial in guiding and supporting students' self-assessment (Lubbe & Mentz, 2021).

In the context of education, social constructivism highlights the significance of active engagement, dialogue and reflection in the learning process (Vygotsky, 1978). Students can actively interact with Gen AI-driven educational tools, Bloom's taxonomy-based assessments, and critical thinking activities in self-directed learning environments. These interactions, both with peers and technology, can facilitate the co-construction of knowledge, the development of higher-order thinking skills and the cultivation of self-directed learning skills.

Social constructivism recognizes that assessment pedagogy is about measuring achievements and supporting students' growth and development. By integrating Gen AI, Bloom's taxonomy and critical thinking into assessment practices, educators can create opportunities for active engagement and reflection throughout the learning process, thus enabling students to make informed decisions about their educational journey.

3 Aim of this study

This research explores the affordances of the amalgamation of artificial intelligence, Bloom's taxonomy and critical thinking to support assessment pedagogy for self-directed learning.

4 Methods

According to van Wee and Banister (2016, p. 278), literature review papers “are often very helpful for researchers, as the reader gets an up-to-date and well-structured overview of the literature in a specific area, and the review adds value”. Through a comprehensive literature review design, existing scholarly work on AI, Bloom’s taxonomy, critical thinking and self-directed learning was analyzed and synthesized to provide a qualitative overview of the current literature. Beyond summarizing scholarly work on AI, Bloom’s taxonomy, critical thinking and SDL, this paper integrates pieces of literature and highlights directions for future research (Gilson & Goldberg, 2015). This multidisciplinary approach allows us to draw connections and explore the potential synergies between these distinct yet interconnected concepts to broaden the scope of thinking (Cropanzano, 2009) and to provide a theoretical explanation for connected concepts (Jaakkola, 2020).

4.1 Search methods

The methodology involved an extensive search of academic databases, research repositories and reputable sources to gather scholarly articles. Figure 2 outlines the literature search process.

Inclusion criteria were employed to select relevant literature that focuses on integrating AI, Bloom’s taxonomy, critical thinking and self-directed learning within the higher education context. Table 1 provides a detailed overview of the query strings used to identify relevant publications in the literature search. Each query string reflects the study’s focus on integrating artificial intelligence, Bloom’s taxonomy, critical thinking, and self-directed learning within higher education assessment. Including specific keywords ensured a targeted search, capturing publications that directly addressed the research objectives.

The inclusion and exclusion criteria listed in Table 2 were applied during the selection process. These criteria were designed to ensure that only peer-reviewed journal articles published in English and directly relevant to the study’s focus were included. The time frame was specifically chosen to capture articles published after the launch of ChatGPT in November 2022, reflecting the rapidly evolving role of generative AI in education.

Since ChatGPT was launched on 30 November 2022 by OpenAI (OpenAI, 2022), only articles published between 30 November 2022 and 22 March 2024 were included in this literature review. The launch of ChatGPT over two years ago illuminated the use of Gen AI in higher education. Only peer-reviewed journal articles were included, and journal reviews were excluded. Since this study has a distilled focus on higher education, only articles relevant to assessment within the higher education context were included. Lastly, only articles published in English were included. After applying the five criteria (Table 2) and after omitting duplicated articles, a total of 24 articles were extracted and included in this comprehensive literature review (see Annexure A).

TOPIC, SCOPING, AND ELIGIBILITY	Topic	Cultivating independent thinkers: The triad of artificial intelligence, Bloom's taxonomy and critical thinking in assessment pedagogy
	Scope and Coverage	Database: SCOPUS and Web of Science Search field: Article title, abstract, keyword Time frame: All Language: English Source type: Journals Document type: Articles
	Keywords	Artificial intelligence (AI), Bloom's taxonomy (BT), critical thinking (CT), self-directed learning (SDL) (see Table 1)

IDENTIFICATION	Date: databases accessed and queried	<p style="text-align: center;">22 – 03 – 2024</p> <pre> graph TD AI[AI] --> SCOPUS[SCOPUS] AI --> WoS[Web of Science] SCOPUS --> AHE[Assessment in Higher Education] WoS --> AHE AHE --> CT[Critical Thinking] AHE --> BT[Bloom's Taxonomy] AHE --> SDL[Self-Directed Learning] </pre>

Fig. 2 Literature search process

Thematic analysis was conducted following the six-step framework Braun and Clarke (2006) outlined. First, the data familiarization stage involved thoroughly reading and re-reading the 24 selected articles to identify patterns and gain an in-depth understanding of the content. Secondly, initial codes were generated using a deductive approach based on the study's focus on generative AI, Bloom's taxonomy, critical thinking, and self-directed learning. Key phrases, concepts, and recurring themes were highlighted manually and through qualitative data analysis software to ensure accuracy.

Third, these codes were grouped into broader themes by examining their relationships and identifying overarching patterns. For instance, themes related to AI literacy, assessment practices, and Bloom's taxonomy's higher-order cognitive levels emerged. Fourth, themes were reviewed and refined to ensure internal coherence and external distinctiveness, discarding or merging themes that lacked sufficient evidence or clarity. Fifth, each theme was clearly defined and named, capturing its essence and relevance to the research questions.

Finally, the write-up integrated these themes into the results and discussion sections. This process was iterative and reflexive, ensuring the themes were grounded in the data and aligned with the study's objectives. By following this transparent approach, the trustworthiness and replicability of the thematic analysis were enhanced. The results are presented in Table 3 below and will be subsequently presented.

Table 1 Query strings used to find publications from selected literature database

Keywords	Query string	Found
Bloom's Taxonomy	("Bloom's taxonomy") AND ("artificial intelligence") AND ("higher education") AND ("assessment")	11
Critical Thinking	("Critical thinking") AND ("artificial intelligence") AND ("higher education") AND ("assessment")	17
Self-Directed Learning	("Self-directed learning") AND ("artificial intelligence") AND ("higher education") AND ("assessment")	2

Table 2 Inclusion and exclusion criteria for publications

Criteria	Description
Criteria 1	Search years 2022–11–30 to 2024–03–22
Criteria 2	Only include source types classified as journals
Criteria 3	Remove journal reviews
Criteria 4	Select only articles relevant to assessment in higher education
Criteria 5	Select only articles in English that have been published

5 Results

This study critically reviews the literature on integrating Gen AI, particularly ChatGPT, with a central focus on exploring the affordances of the amalgamation of artificial intelligence, Bloom's taxonomy and critical thinking to support assessment pedagogy for self-directed learning. The articles spanned across a variety of disciplines, including the healthcare and the education sector (Table 3).

From Table 3, it is evident that ChatGPT has the potential to not only generate an array of questions (Gamage et al., 2023; Indran et al., 2024; Nasution, 2023; Rudolph et al., 2023; Ülkü, 2023) but is also capable of successfully answering questions at different cognitive levels in a variety of disciplines (Herrmann-Werner, Festl-Wietek, Holderried, Herschbach et al. 2024; Nikolic et al., 2023; Sallam & Al-Salahat, 2023; Sinha et al., 2023; Ülkü, 2023). Zhai et al. (2024) investigated whether Gen AI can outperform humans in solving cognitive-demanding science problems, revealing that AI models consistently outperformed students in the US National Assessment of Educational Progress science assessments. This finding prompts a re-evaluation of educational objectives in response to the potential of Gen AI surpassing human performance in cognitive tasks. Moreover, the study highlights the importance of developing advanced cognitive skills beyond basic knowledge acquisition to prepare students for an AI-driven future. Generative AI's ability to solve authentic assessments emphasizes the importance of academic integrity and a reconceptualization of assessment practices in higher education instead of limiting educators' role in tracking and policing unethical use.

The reviewed studies provide insights into how Gen AI can address certain levels of Bloom's taxonomy, particularly Remembering and Understanding, as demonstrated in studies such as Nasution (2023) and Zaman et al. (2024). However, alignment with the proposed theoretical framework in this study is limited, particularly in addressing higher-order cognitive levels like Evaluating and Creating. For example, Thanh, Vo, Nhat, Pham, et al. (2023) and Zhai et al. (2024) highlight Gen AI's potential at the 'Create' level but do not integrate this with the iterative feedback loop suggested by the social constructivist approach. Similarly, while several studies explore AI's role in fostering critical thinking (e.g., Lo, 2023; Rudolph et al., 2023), they lack a comprehensive focus on how AI can scaffold self-directed learning through interactive engagement. These divergences underscore the need for a framework that systematically integrates Gen AI into assessment pedagogy to enhance critical thinking and self-directed learning.

Table 3 Articles and key findings

Article Title	Research Area	Key Findings
Examining the Threat of ChatGPT to the Validity of Short Answer Assessments in an Undergraduate Medical Program (Morjaria et al., 2023)	Education & Educational Research	<ul style="list-style-type: none"> • ChatGPT showed a good correlation with human assessors scoring short-answer assessments, indicating it could be a viable assistant for grading • There is a need for careful integration of Gen AI tools when rubrics are used to score students' work to ensure fair and accurate assessment • Highlights the potential for Gen AI to reduce university staff's grading workload, allowing educators more time for student interaction
ChatGPT performance in diagnostic clinical microbiology laboratory-oriented case scenarios (Sallam, 2023)	Education & Educational Research	<ul style="list-style-type: none"> • Both ChatGPT models showed variability across different diagnostic scenarios with success • ChatGPT-4 consistently outperformed ChatGPT-3.5
Race with the machines: Assessing the capability of generative AI in solving authentic assessments (Thanh et al., 2023)	Education & Educational Research	<ul style="list-style-type: none"> • Gen AI tools like ChatGPT-4 and ChatGPT-3.5 performed well at lower levels of Bloom's taxonomy (remember and understand), but their effectiveness decreased at higher levels (create) • Advocates for a focus on the 'create' level of Bloom's taxonomy
Twelve tips to leverage AI for efficient and effective medical question generation: A guide for educators using Chat GPT (Indran et al., 2023)	Education & Educational Research; Health Care Sciences & Services	<ul style="list-style-type: none"> • Gen AI can rapidly produce a wide array of assessment questions (that span various cognitive levels of Bloom's taxonomy), which helps educators reduce the time and effort spent on question creation • Gen AI's output requires human oversight to ensure accuracy, relevance, and alignment with educational goals • The role of educators in reviewing and refining AI-generated content is highlighted as crucial • Ensuring the ethical use of Gen AI and maintaining academic integrity is paramount

Table 3 (continued)

Article Title	Research Area	Key Findings
ChatGPT versus engineering education assessment: a multidisciplinary and multi-institutional benchmarking and analysis of this generative artificial intelligence tool to investigate assessment integrity (Nikolic et al., 2023)	Education & Educational Research	<ul style="list-style-type: none"> • ChatGPT could pass some engineering assessments with minimal input modifications • Highlights potential uses of ChatGPT in facilitating learning, such as generating tutorial questions, aiding in problem-solving, and providing explanations or summaries for complex engineering concepts • Raises concerns about assessment integrity, as ChatGPT could potentially be used to bypass traditional forms of evaluation like essays and problem-solving exercises • Shows how important it is to keep assessing how the influence is affecting teaching methods • Makes the case that assessment techniques used in engineering education may need to be modified in order to determine true student comprehension and proficiency
Artificial intelligence-based large language models and integrity of exams and assignments in higher education: the case of tourism courses (Ülkü, 2023)	Social Sciences	<ul style="list-style-type: none"> • ChatGPT-4 can generate, answer and critique questions across various sub-disciplines like tourism marketing, management, economics, tourist guidance and gastronomy with a commendable competence in several critical thinking standards • The AI's ability to generate competent responses can be exploited for cheating, posing a threat to academic honesty • Stresses the significance of upholding academic honesty and the moral application of ChatGPT in evaluation procedures
ChatGPT and higher education assessments: More opportunities than concerns? (Gamage et al., 2023)	Education & Educational Research	<ul style="list-style-type: none"> • Suggests that AI could allow educators to focus more on developing and assessing higher-order thinking skills • Stresses the importance of addressing ethical concerns and the dependability of Gen AI tools in assessments to ensure they enhance student learning and maintain educational standards

Table 3 (continued)

Article Title	Research Area	Key Findings
Using artificial intelligence to create biology multiple choice questions for higher education (Nasution, 2023)	Education & Educational Research	<ul style="list-style-type: none"> • ChatGPT can create multiple-choice questions for biology topics, typically covered in high school and university courses, that are valid and reliable • ChatGPT can be a useful tool in helping to create assessment materials that are relevant and easy to comprehend for the intended audience • Teachers can create a variety of useful assessment tools more quickly by utilizing ChatGPT's ability to produce questions that correspond with educational standards • Indicates that human review is required to guarantee the questions fulfill all learning goals and remain of high quality
ChatGPT: Bullshit spewer or the end of traditional assessments in higher education? (Rudolph et al., 2023)	Education & Educational Research	<ul style="list-style-type: none"> • ChatGPT can quickly generate coherent and contextually appropriate text responses • ChatGPT has occasional inaccuracies and its inability to understand content deeply or verify factual accuracy are pointed out as limitations • Brings up questions regarding academic honesty and possible ChatGPT cheating abuse • Recognize the potential for improving teaching methods with assessments powered by Gen AI • Reassessing techniques of instruction and evaluation is required to guarantee that the potential of Gen AI is utilized while maintaining the objectives of education
Dataset of computer science course queries from students: Categorized and scored according to Bloom's taxonomy (Zaman et al., 2024)	Science & Technology	<ul style="list-style-type: none"> • Highlights the importance of leveraging Bloom's taxonomy for question design optimization and promoting critical thinking skills among students

Table 3 (continued)

Article Title	Research Area	Key Findings
Assessing ChatGPT's Mastery of Bloom's Taxonomy Using Psychosomatic Medicine Exam Questions: Mixed-Methods Study (Herrmann-Werner et al., 2024)	Health Care Sciences & Services	<ul style="list-style-type: none"> • While ChatGPT holds promise in assisting healthcare professionals with assessment • Addressing inherent biases and ensuring accuracy is crucial for their successful integration into clinical practice • Emphasizes the need to validate AI-generated responses and ensure alignment assessment criteria
Can Generative AI and ChatGPT Outperform Humans on Cognitive-Demanding Problem-Solving Tasks in Science? (Zhai et al., 2024)	Education & Educational Research	<ul style="list-style-type: none"> • Prompts a re-evaluation of educational objectives in response to the potential of Gen AI surpassing human performance in cognitive tasks • Indicates the importance of developing advanced cognitive skills beyond basic knowledge acquisition to prepare students for an AI-driven future and foster self-directed learning
Applicability of ChatGPT in assisting to solve higher order problems in pathology (Sinha et al., 2023)	Health Care Sciences & Services	<ul style="list-style-type: none"> • ChatGPT demonstrates a high level of accuracy in providing meaningful responses • Underscores the potential of Gen AI to enhance problem-solving capabilities in healthcare, particularly in pathology diagnosis and decision-making processes
Towards Mitigating ChatGPT's Negative Impact on Education: Optimizing Question Design Through Bloom's Taxonomy (Elsayed, 2023)	Education & Educational Research	<ul style="list-style-type: none"> • Proposes an evolutionary approach to optimize question design using higher levels of Bloom's taxonomy, aiming to foster critical thinking among students
Is the laboratory report dead? AI and ChatGPT (Wang, 2023)	Microbiology	<ul style="list-style-type: none"> • ChatGPT's limitations to answering higher-order level questions during lab work • Cautions against the overreliance on Gen AI for tasks that require high-order cognitive skills • Emphasizes the need for human intervention in specifying laboratory conditions, reading results and critically reporting on those results

Table 3 (continued)

Article Title	Research Area	Key Findings
Get out of the BAG! Silos in AI Ethics Education: Unsupervised Topic Modeling Analysis of Global AI Curricula (Javed et al., 2022)	Computer Science	<ul style="list-style-type: none"> Emphasizes that creativity and ethics are essential components of Gen AI integration in higher education
The dark side of artificial intelligence in higher education (Ivanov, 2023)	Business & Economics	<ul style="list-style-type: none"> The use of Gen AI is not without its challenges Provides examples of how Gen AI is used in higher education institutions to make decisions Shows how human-only, human-in-the-loop, human-on-the-loop, and human-out-of-the-loop approaches to Gen AI are all possible Advocates for ethical approaches, creativity and critical thinking should be not an afterthought but an essential component
Improving Quality of Online Teaching, Finance and Business Management Using Artificial Intelligence and Backward Design (Mosteanu, 2022)	Business & Economics	<ul style="list-style-type: none"> Highlights the gap between Gen AI's potential and the actual knowledge and skills required to implement AI effectively in higher education Argues that the emphasis should be on the education system to adapt and evolve to incorporate Gen AI technologies in ways that are pedagogically sound and aligned with educational goals Even though Gen AI holds promise for enhancing the educational experience, particularly in the context of online teaching, university staff and students should be educated in the practical application of Gen AI in teaching and learning
Factors influencing students' intention to adopt and use ChatGPT in higher education: A study in the Vietnamese context (Maheshwari, 2023)	Education & Educational Research	<ul style="list-style-type: none"> Evidence suggests that while students recognize the potential of ChatGPT for enhancing their learning experience, its value is intertwined with its ability to engage users in meaningful, interactive and critical learning experiences

Table 3 (continued)

Article Title	Research Area	Key Findings
ChatGPT—A Challenging Tool for the University Professors in Their Teaching Practice (Zhang et al., 2023)	Education & Educational Research	<ul style="list-style-type: none"> • The authors argue that caution toward AI but an overall positive adoption toward the use of ChatGPT in the academic setting • For the effective use of ChatGPT in education, thoughtful integration into the curriculum and policy development needs to be done to address the potential risks and ethical concerns associated with the use of AI
Students' Perception of ChatGPT Usage in Education (Valova et al., 2024)	Education & Educational Research	<ul style="list-style-type: none"> • Students show interest in the rapid adoption of ChatGPT for instant assistance and potential enhancement of their learning experiences through personalized feedback and engagement • Students did raise concerns about the potential for misuse, particularly regarding academic integrity and the risk of over-reliance on Gen AI-generated content without critical evaluation
Reforming higher education with ePortfolio implementation, enhanced by learning analytics (Pospíšilová & Rohlfiková, 2023)	Education & Educational Research	<ul style="list-style-type: none"> • Argues for the use of e-portfolios in an AI environment • e-Portfolios and learning analytics in higher education can support the development of 21st-century skills such as self-reflection, digital literacy and critical thinking, focusing on AI's role in enhancing student engagement and personalized learning
Learning to work with the black box: Pedagogy for a world with artificial intelligence (Bearman & Ajjawi, 2023)	Education & Educational Research	<ul style="list-style-type: none"> • Emphasizes the importance of preparing students for an AI-dominated world • Argues that education should impart knowledge and teach students to navigate the complexity of an unknown future • It states the importance of developing student agency, ethical thinking, and knowledge creation within an AI-dominated world where students should foster evaluative judgment and meaningful interactions with Gen AI

Table 3 (continued)

Article Title	Research Area	Key Findings
What is the impact of ChatGPT on education? A rapid review of the literature (Lo, 2023)	Education & Educational Research	<ul style="list-style-type: none">• Discusses the benefits of using ChatGPT as a scaffolding tool in education focusing on using prompts to question and enhance students' writing and research skills• Makes it clear that we should caution against letting Gen AI replace critical thinking and original work, suggesting that future assessments should aim for higher cognitive skills in Bloom's taxonomy

According to Thanh et al. (2023), assessments should have a more distilled focus on higher levels of Bloom's taxonomy, specifically at the 'Create' level. Wang (2023) addressed the effectiveness and limitations of Gen AI, especially in the responses during laboratory work. Wang (2023) cautions against the overreliance on Gen AI for tasks that require high-order cognitive skills and emphasize the need for human intervention in specifying laboratory conditions, reading results, and critically reporting on those results. Javed, Nasir, Borit, Vanhée, et al. (2022), just like Wang (2023), highlighted the need for critical thinking. In the article of Bearman et al. (2023), the authors emphasize the importance of preparing students for an AI-dominated world. They argue that education should impart knowledge and teach students to navigate the complexity of an unknown future. They further state that it is important to develop student agency, critical thinking and knowledge creation within an AI-dominated world where students should foster evaluative judgment and meaningful interactions with Gen AI systems. Lo (2023) discussed the benefits of using ChatGPT as a scaffolding tool in education, focusing on using prompts to question and enhance students' writing and research skills. However, Lo (2023) further clarifies that we should caution against letting AI replace critical thinking and original work, suggesting that future assessments should aim for higher cognitive skills in Bloom's taxonomy. Mosteanu (2022) and Maheshwari (2023) agree that Gen AI holds promise for enhancing the educational experience, particularly in the context of online teaching, but both university staff and students should be educated in the practical application of Gen AI in teaching and learning. Kiryakova and Angelova (2023) examined university staff's perceptions of Gen AI, specifically ChatGPT. They illustrated that while a large portion of university staff may have limited knowledge, they should be cautioned against the misuse of Gen AI, particularly in undermining academic integrity. Hence, AI fluency is needed among university staff and students.

Studies such as Gamage et al. (2023) and Nasution (2023) underscore the utility of generative AI in automating assessment creation and fostering personalized learning experiences. However, Rudolph et al. (2023) and Wang (2023) highlight the limitations of AI when addressing higher-order cognitive processes, such as evaluation and creation, raising concerns about its capacity to foster truly independent, critical thinkers. These opposing perspectives reflect an ongoing tension: while AI offers efficiency and scalability, its reliability in supporting the nuanced goals of higher education remains uncertain.

A significant gap emerges regarding AI in pedagogy. While Thanh et al. (2023) and Zhai et al. (2024) emphasize the importance of targeting the higher levels of Bloom's taxonomy, including evaluation and creation, there is little practical guidance for educators on how to achieve this integration effectively. This gap is particularly significant given the rapid pace of AI adoption in education. Without concrete frameworks and actionable strategies, educators are left navigating uncharted territory, which undermines the potential benefits of generative AI in advancing critical thinking and self-directed learning.

Another critical issue is the role of educators in managing AI-driven learning environments. While studies like Indran et al. (2023) and Zhang et al. (2023)

suggest that AI can alleviate educators' workloads by automating routine tasks, Ülkü (2023) and Wang (2023) argue that these technologies introduce new challenges, such as the need to validate AI-generated outputs and address ethical concerns about academic integrity. This contradiction points to an unresolved question: Does AI ultimately empower or burden educators in achieving their pedagogical goals? Furthermore, a recurring theme across the literature is the lack of a shared understanding of AI literacy. While Bearman et al. (2023) and Lo (2023) advocate equipping students with the skills to critically evaluate AI-generated content, the specific pedagogical strategies for fostering such evaluative judgment remain underexplored—this absence of clarity limits the development of scalable approaches to promoting critical thinking in AI-driven learning contexts. What is evident from Table 3 is that none of the articles in this comprehensive literature review made a case for harnessing the full potential of Gen AI and leveraging Bloom's taxonomy for promoting critical thinking skills to support self-directed learning. Although several articles presented a case for utilizing Bloom's taxonomy for higher-level question design, highlighting the need for developing critical thinking skills (Elsayed, 2023; Thanh et al., 2023; Zaman, Islam, Islam, & Sayed, 2024), we identified a lacuna regarding the need to revisit Bloom's taxonomy in an AI-dominated world.

6 Discussion

Faculty in higher education often find it challenging to facilitate creativity of thought and critical thinking (Halupa, 2021). Since the 1950s, Bloom's taxonomy levels have often been depicted as a stairway, leading educators to support students to climb to a higher level (Forehand, 2010). The "climbing" aspect of Bloom's taxonomy may lead to misinterpretation to the extent that the development of higher-order thinking skills is seen as a linear process (climbing up and not necessarily up and down). According to Halupa (2021), it can be challenging to design pertinent, authentic assessments that demand that students demonstrate mastery of higher-order thinking skills. In an AI-driven higher education context, with Gen AI being capable of successfully designing, constructing, developing and formulating, the development of critical thinking skills is crucial.

Since Gen AI can be used to answer an array of assessment questions on all cognitive levels, human intervention and critical analysis are needed for all content created by Gen AI. Due to the verisimilitude of Gen AI responses, assessment should not only focus on remembering and understanding but also foster the ability to analyze and evaluate these responses. This engagement with AI-generated responses fosters ethical and critical reasoning (Bearman et al., 2023), ultimately contributing to the development of SDL (Loeng, 2020). The twenty-first century requires individuals to have critical thinking and self-directed learning skills (Wasyilah, Yusrizal, & Suhrawardi, 2021). Self-directed learning involves individuals taking charge of their learning process, planning and executing activities to enhance knowledge and skills (Knowles, 1975). This fosters independence and encourages students to think critically by analyzing information, evaluating evidence and problem-solving

(Loeng, 2020). Implementing assessment as a pedagogical practice enables the student to critically evaluate and analyze information through self- and peer assessment (Lubbe & Mentz, 2021). Generative AI is a tool that can be used to scaffold students' learning during the assessment process (Lo, 2023), hence playing a positive role in assessment pedagogy.

Revisiting Bloom's taxonomy, especially the evaluation and creativity levels, can help educators develop better assessments that encourage critical thinking and support students in becoming independent learners. With Gen AI's capacity to operate across all levels of Bloom's taxonomy, educators need to evaluate what they want their students to learn. Since Gen AI can create, students should be guided and supported in evaluating and analyzing AI-created text in order to evaluate its reliability and trustworthiness. Therefore, Gen AI's capacity to operate across Bloom's taxonomy levels presents an opportunity to enhance students' engagement with material in more analytical and creative ways, which are essential for critical thinking and self-directed learning. Critical thinking, as facilitated through the interaction with AI-generated content, requires students not only to engage with but also to scrutinize and challenge the AI-generated information. This process is vital in cultivating independent self-directed students who can navigate the complexities of a technologically advanced world. Revisiting Bloom's taxonomy to place *evaluate* at the top is grounded in its critical role in fostering higher-order thinking, particularly in an AI-driven educational landscape (see Fig. 3). Studies such as Thanh et al. (2023) and Lo (2023) emphasize the increasing importance of critical evaluation when engaging with AI-generated content. Krathwohl's (2002) revision highlights the cyclical relationship between *evaluate* and *create*, suggesting that evaluating content often informs and enhances creative processes. This reordering also emphasizes the dynamic interplay between evaluating and creating, which is particularly relevant in an AI-driven educational context where students must not only generate content but also critically assess its validity, relevance, and ethical implications. There should be a constant movement between all levels of Bloom's taxonomy and even more so between *evaluate* and *create* as students' ability to ask the right questions (creating prompts) and evaluating the results will influence not only the quality of the responses but also students' evaluation skills. As illustrated in Fig. 3, there should be a feedback loop between 'evaluate' and 'create'. This adjustment reflects the growing importance of evaluative skills in an AI-integrated educational landscape. Rather than viewing Bloom's taxonomy as a linear progression. This calls for encouraging students to continually revisit earlier stages as they refine their understanding and output. Empirical findings from Gamage et al. (2023) and Wang (2023) also suggest that tasks requiring critical evaluation lead to deeper learning and improved student autonomy, further validating this proposed adjustment.

In adapting our approach to assessment and focusing on students' critical thinking, it can be argued that Gen AI can play a supportive role for self-directed learning. With students taking control of their own education, generating AI-responses and evaluating those responses, students not only learn how to use AI but evaluate the responses in a self-directed manner.

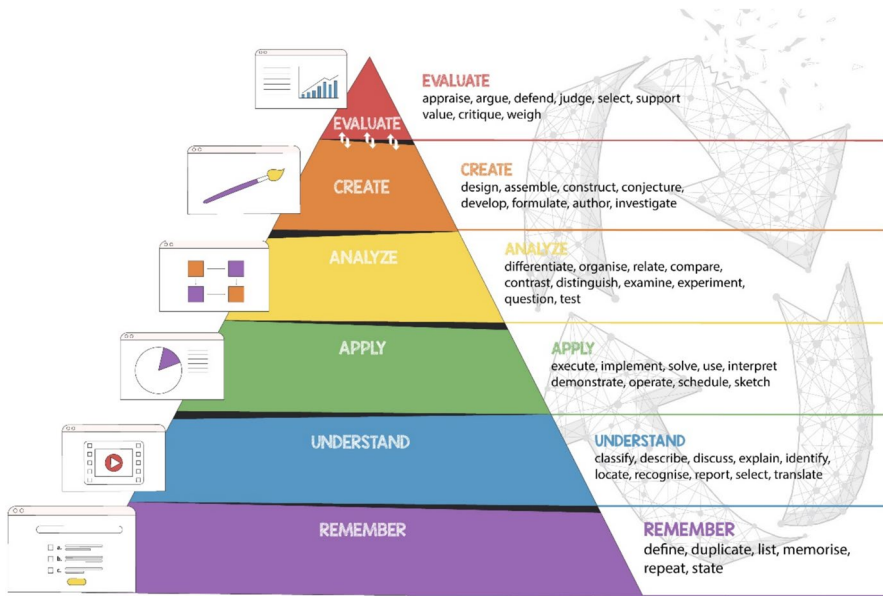


Fig. 3 Bloom's taxonomy in an AI-driven higher education context

7 Practical recommendations for educators

In proposing a revision of Bloom's taxonomy in an AI-integrated educational context, some recommendations for educators may include the following:

a) Integrate AI evaluation as a skill

Educators should design tasks that require students to critically evaluate AI-generated content before applying or revising it. For example, in a literature course, students could use ChatGPT to generate a thematic analysis of a novel but would need to evaluate the accuracy, relevance, and biases of the AI's response before incorporating it into their final analysis. This fosters critical thinking by requiring students to assess the quality and reliability of AI outputs.

b) Scaffold AI across Blooms taxonomy

Assignments should guide students through all levels of the revised taxonomy, moving between lower-order and higher-order skills. For instance, in a history class, students could start by using AI to summarise key events (understand), analyze the causes and effects of those events (analyze), evaluate the AI-generated analysis for biases or inaccuracies (evaluate), and finally form an argument.

c) Promote ethical AI engagement

Educators should incorporate discussions and activities that encourage the ethical use of AI. For example, students could be tasked with generating a research question, using AI to find initial sources, and evaluating those sources for credibility and ethical implications before creating their own annotated bibliography or research proposal.

d) Promote collaborative evaluation activities

Encourage peer collaboration where students evaluate each other's use of AI tools and outputs. For example, in a business class, teams could design a marketing plan using AI and then present and critique each other's strategies to refine their evaluation of the generated material.

e) Revise assessment practices

Assessments should focus not only on the output but also on the process, particularly students' ability to evaluate and refine AI-generated content. Rubrics should include criteria for evaluating the appropriateness, reliability, and originality of AI-assisted work with content knowledge.

f) Encourage reflective practice

Incorporate reflective writing or oral presentations where students discuss their process of using AI, the challenges they faced, and how they addressed issues of accuracy, bias, or creativity.

8 Limitations

This study provides valuable insights into the integration of generative AI, Bloom's taxonomy, and critical thinking in higher education but has several limitations. As a conceptual research study based on a systematic literature review, it does not include empirical data or classroom-based experiments, meaning the proposed framework for revising Bloom's taxonomy remains theoretical and untested in practice. The literature reviewed is limited to English-language publications indexed in Scopus and Web of Science, which may exclude relevant findings from non-English sources or other academic repositories, reducing the global applicability of the conclusions. Additionally, the focus is confined to higher education, leaving out other educational contexts such as secondary schools, vocational training, and informal learning environments, where the dynamics of AI integration may differ. Furthermore, given the rapid pace of advancements in generative AI, the findings of this study may require updates as the technology evolves and its applications in education expand.

9 Conclusion

The potential of Gen AI to transform educational assessment is evident, offering opportunities to enhance both teaching and learning experiences. By aligning assessment practices with the capabilities of Gen AI, lecturers can effectively promote critical thinking skills and prepare students for the complexities of the modern world. However, this transformation requires careful consideration of the pedagogical, ethical and cognitive implications of integrating AI into educational frameworks. The future of education with Gen AI promises to enhance cognitive skills and foster a generation of students who evaluate and use Gen AI. In an era where Gen AI tools are readily available and used across educational settings to create, design, invent, compose, plan, formulate, generate, hypothesize, produce, develop, arrange and construct with a great level of accuracy and reliability, revisiting Bloom's taxonomy is crucial.

The findings benefit educators seeking to design more effective and student-centric assessment practices, ultimately striving to enhance self-directed learning in an era of rapid technological advancement. This research opens several avenues for future exploration. Empirical studies are needed to test the proposed reframing of Bloom's taxonomy in real-world educational settings, evaluating its impact on critical thinking and self-directed learning. Additionally, longitudinal research could examine how generative AI influences students' ability to navigate higher-order cognitive tasks over time. Investigating the scalability of this framework across diverse educational contexts, including secondary education and vocational training, would also provide valuable insights. Lastly, this paper stresses the importance of creating assessments on higher-order cognitive skills and supporting students in navigating Bloom's taxonomy levels to cultivate critical thinking for self-directed learning.

Anexure 1

Article Title	Authors	Source Title	Author Key-words	Publication Date	Research Area
Examining the Threat of ChatGPT to the Validity of Short Answer Assessments in an Undergraduate Medical Program	Morjaria et al	JOURNAL OF MEDICAL EDUCATION AND CURRICULAR DEVELOPMENT	undergraduate; medical student; pre-clerkship; ChatGPT; artificial intelligence; short answer assessment	2023	Education & Educational Research
Below average ChatGPT performance in medical microbiology exam compared to university students	Sallam & Al-Salahat	FRONTIERS IN EDUCATION	educational research; artificial intelligence; MCQ; cognitive; reasoning	2023	Education & Educational Research
Race with the machines: Assessing the capability of generative AI in solving authentic assessments	Thanh et al	AUSTRALASIAN JOURNAL OF EDUCATIONAL TECHNOLOGY	authentic assessment; Bloom's taxonomy; generative AI; AI in tertiary education; quantitative; case study	2023	Education & Educational Research

Article Title	Authors	Source Title	Author Key-words	Publication Date	Research Area
Twelve tips to leverage AI for efficient and effective medical question generation: A guide for educators using Chat GPT	Indran et al	MEDICAL TEACHER	Chat GPT; AI; medical assessment; questions	2023	Education & Educational Research; Health Care Sciences & Services
ChatGPT versus engineering education assessment: a multidisciplinary and multi-institutional benchmarking and analysis of this generative artificial intelligence tool to investigate assessment integrity	Nikolic et al	EUROPEAN JOURNAL OF ENGINEERING EDUCATION	Artificial intelligence (AI); assessment; ChatGPT; engineering education; GPT-3; integrity	2023	Education & Educational Research
Artificial intelligence-based large language models and integrity of exams and assignments in higher education: the case of tourism courses	Ülkü	TOURISM & MANAGEMENT STUDIES	Large Language Models (LLM); Artificial Intelligence; ChatGPT; Tourism Education; Exams; Integrity	2023	Social Sciences
Exploration of a group assessment model to foster student teachers' critical thinking	Zhang et al	THINKING SKILLS AND CREATIVITY	Improving classroom teaching; Cooperative; collaborative learning; Teaching; learning strategies; twenty-first century abilities	2023	Education & Educational Research

Article Title	Authors	Source Title	Author Key-words	Publication Date	Research Area
Redesign of online proctored exams for STEM learners in higher education institutions: proposal for incorporating higher-order thinking skills and democratic pedagogy via OPERHOT platform	Mitra	FEMS Microbiology Letters	STEM education; Democratic STEM pedagogy; Proctored exams; Higher-order thinking skills; Online assessment; Assessment Integrity	2023	Education & Educational Research
ChatGPT and higher education assessments: More opportunities than concerns?	Gamage et al	Journal of Applied Learning and Teaching	Academic integrity; Artificial intelligence; Assessments; ChatGPT; Higher education; Learning and teaching; Quality assurance	2023	Education & Educational Research
Using artificial intelligence to create biology multiple choice questions for higher education	Nasution	Agricultural and Environmental Education	ChatGPT; Multiple choice questions; Artificial intelligence; Validity; Reliability	2023	Education & Educational Research

Article Title	Authors	Source Title	Author Key-words	Publication Date	Research Area
ChatGPT: Bullshit spewer or the end of traditional assessments in higher education?	Rudolph et al	Journal of applied learning and teaching	Artificial intelligence; Artificial intelligence in Education; Assessment; ChatGPT; Generative Pre-Trained Transformer 3; Higher education; Learning and teaching; Natural language processing	2023	Education & Educational Research
Dataset of computer science course queries from students: Categorized and scored according to Bloom's taxonomy	Zaman et al	DATA IN BRIEF	Education; Academic learning; Questioning; Computer science; Artificial intelligence; Machine learning	2024	Science & Technology

Article Title	Authors	Source Title	Author Key-words	Publication Date	Research Area
Assessing ChatGPT's Mastery of Bloom's Taxonomy Using Psychosomatic Medicine Exam Questions: Mixed-Methods Study	Herrmann-Werner et al	JOURNAL OF MEDICAL INTERNET RESEARCH	answer; artificial intelligence; assessment; Bloom's taxonomy; ChatGPT; classification; error; exam; examination; generative; GPT-4; Generative Pre-trained Transformer 4; language model; learning outcome; LLM; MCQ; medical education; medical exam; multiple-choice question; natural language processing; NLP; psychosomatic; question; response; taxonomy	2024	Health Care Sciences & Services
Can Generative AI and ChatGPT Outperform Humans on Cognitive-Demanding Problem-Solving Tasks in Science?	Zhai et al	SCIENCE & EDUCATION	Generative artificial intelligence (GAI); ChatGPT; GPT-4; NAEP; Science assessment; Cognitive load; Problem-solving	2024	Education & Educational Research
Applicability of ChatGPT in assisting to solve higher order problems in pathology	Sinha et al	Cureus		2023	Health Care Sciences & Services

Article Title	Authors	Source Title	Author Key-words	Publication Date	Research Area
Towards Mitigating ChatGPT's Negative Impact on Education: Optimizing Question Design Through Bloom's Taxonomy	Elsayed	IEEE Region 10 Symposium (TEN-SYMP)		2023	
Is the laboratory report dead? AI and ChatGPT	Wang	MICROBIOLOGY AUSTRALIA	artificial intelligence; assessment; Bloom's taxonomy; ChatGPT; laboratory report	2023	Microbiology
Get out of the BAG! Silos in AI Ethics Education: Unsupervised Topic Modeling Analysis of Global AI Curricula	Javed et al	JOURNAL OF ARTIFICIAL INTELLIGENCE RESEARCH		2022	Computer Science
The dark side of artificial intelligence in higher education	Ivanov	SERVICE INDUSTRIES JOURNAL	Artificial intelligence; higher education; negative impacts; ethics; decision-making approaches	2023	Business & Economics
Improving Quality of Online Teaching Finance and Business Management Using Artificial Intelligence and Backward Design	Mosteanu	QUALITY-ACCESS TO SUCCESS	artificial intelligence; backward design; finance and business management; quality of teaching and learning	2022	Business & Economics

Article Title	Authors	Source Title	Author Key-words	Publication Date	Research Area
Factors influencing students' intention to adopt and use ChatGPT in higher education: A study in the Vietnamese context	Maheshwari	EDUCATION AND INFORMATION TECHNOLOGIES	ChatGPT; Human-computer interface; Adoption intention; Vietnam; Higher education	2023	Education & Educational Research
ChatGPT-A Challenging Tool for the University Professors in Their Teaching Practice	Zhang et al	THINKING SKILLS AND CREATIVITY	artificial intelligence; ChatGPT; higher education; teaching; university professors' perceptions	2023	Education & Educational Research
Students' Perception of ChatGPT Usage in Education	Valova et al	International Journal of Advanced Computer Science and Applications		2024	Education & Educational Research
Reforming higher education with ePortfolio implementation, enhanced by learning analytics	Pospíšilová & Rohlíková	Computers in Human Behavior		2023	Education & Educational Research
Learning to work with the black box: Pedagogy for a world with artificial intelligence	Bearman & Ajjawi	British Journal of Educational Technology		2023	Education & Educational Research
What is the impact of ChatGPT on education? A rapid review of the literature	Lo	Education Sciences		2023	Education & Educational Research

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Data availability The relevant data, materials and codes will be made available upon request.

Declarations

Competing interests None of the authors have competing interests to declare.

Ethical approval Ethics approval was obtained from the relevant Ethics Committee from the North-West University [NWU-00307-23-S2].

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Authors and Affiliations

Anitia Lubbe¹  · Elma Marais²  · Donnivan Kruger¹ 

✉ Anitia Lubbe
Anitia.Lubbe@nwu.ac.za

Elma Marais
Elma.Marais@nwu.ac.za

Donnivan Kruger
Donnivan.Kruger@nwu.ac.za

¹ Research Unit Self-Directed Learning, North-West University, Potchefstroom, South Africa

² Research Unit Community-Based Educational Research, North-West University, Potchefstroom, South Africa