



# A systematic literature review on authentic assessment in higher education: Best practices for the development of 21st century skills, and policy considerations

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## ABSTRACT

Authentic assessment methods involve the application of real-world tasks to evaluate students' knowledge, skills, and attitudes in a way that replicates actual situations in which those would be utilized. This paper systematically reviews relevant literature from various disciplines in higher education, focusing on the development of 21st-century skills that can enhance students' employability. The main objectives are to explore both reported effective implementation strategies of authentic assessment and the implications across different stakeholder groups—students, teaching staff, and policy makers. A sample of 94 articles was identified following the pre-defined inclusion criteria. Findings indicate that authentic assessment enhances key employability skills; at the same time, challenges have been identified for its effective implementation, including resistance from some stakeholders and the need for adequate training and resources. This study opens avenues for future research, presenting potential directions, as well as practical implications and policy recommendations emerging from a comprehensive thematic analysis.

## 1. Introduction

The current era of higher education is undergoing significant transformation, driven by rapid technological advancements, disruptions caused by the COVID-19 pandemic and geopolitical instability, as well as an increasing demand for graduates equipped with 21st-century skills. Assessment plays a crucial role in this shift, measuring student knowledge, skills and attitudes through both formative and summative methods (Murphy et al., 2017). Beyond traditional, product-oriented assessments, there is growing recognition of the need for authentic assessment approaches that prioritize real-world applications and practical skills over rote memorization (Sutadji, Susilo, Wibawa, Jabari, Rohmad 2021a, 2021b). This method requires students to engage in complex problem-solving and produce work that mirrors or simulates real-life scenarios, making it a vital tool for developing skills essential for today's workforce. Authentic assessment, increasingly recognized in both face-to-face (Petre, 2017) and online educational settings (Sutadji, Susilo, Wibawa, Jabari, Rohmad 2021a, 2021b; Shikwaya & Amadhila,

2023), presents ongoing challenges and opportunities for research and practice. One opportunity that hasn't been fully addressed is how it specifically contributes to the development of key 21st century skills. This paper addresses this gap by focusing on how authentic assessment enhances these skills, which are crucial for professional development and success in the labor market.

Specifically, this systematic literature review concentrates on empirical studies, conceptual papers and literature reviews that investigate the effectiveness of authentic assessment in fostering these skills. By analyzing the results of prior research, we aim to provide clearer insights into the practical applications of authentic assessment and offer recommendations for higher education stakeholders, including students, educators, and policymakers. In this context, the two research questions that guide this review are:

- How do current studies link authentic assessment with the development of critical 21st-century skills?

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- What are the reported outcomes and implications of using authentic assessment for student learning and skill development across disciplines and different stakeholder perspectives (students, teachers, and administrators)?

The following sections of the paper are organized as follows: [Section 2](#) analyzes major concepts on authentic assessment from theorists and researchers. [Section 3](#) reviews literature, conceptual papers, and reflective essays on applying authentic assessment in higher education, identifying research gaps. [Section 4](#) details the research methodology, including the search process, selection criteria, data collection, and analytical procedures. [Section 5](#) discusses the results, highlighting key themes, such as “effective authentic assessment strategies” across disciplines, the “integration of technology in authentic assessment”, “authentic assessment for enhancing students’ career readiness and professional identity”, and “challenges and opportunities for successful implementation”. [Section 6](#) advocates for moving from traditional to postmodern assessment forms, suggests a future research agenda, and discusses practical and policy implications for stakeholders.

## 2. Conceptualizing authentic assessment

The concept of authentic assessment, though not new, has evolved significantly, with authors emphasizing its authenticity ([Gulikers et al., 2004](#); [Mueller, 2005](#); [Ashford-Rowe et al., 2014](#); [Villarroel et al., 2018](#)), despite a persistent lack of conceptual clarity. Some scholars prefer the term “alternative assessment” ([Kong & Yuen, 2022](#); [Bakar & Sulaiman, 2023](#)), although its integration into higher education curricula remains in its early stages ([Manville et al., 2022](#)). Authentic assessment aims to equip students with skills and work-readiness for post-graduation, contrasting with traditional methods focused on memorization ([Sotiriadou et al., 2020](#)). It is rooted in Piaget’s theory on cognitive development (1974), which highlights the importance of students actively constructing their own knowledge through hands-on experiences rather than passively absorbing information. Piaget’s view suggests that learners build understanding by interacting with their environment, which aligns with the principles of authentic assessment, where students engage in tasks that mirror the demands of their future workplaces. Authentic assessment is also directly linked to Situated Learning Theory ([Lave, 1988](#)),

which posits that learning is most effective when it occurs within the context in which it will be applied, and that students learn best through participation in social and real-life activities that are meaningful and relevant to their future roles. In the same line, [Kasimatis and Papa-georgiou \(2021\)](#) link authentic assessment with the social nature of knowledge and the social constructivist perspectives, which focus on the construction of knowledge through the creation of meaningful and authentic activities. Defined as criterion-referenced assessment that mirrors real-life professional situations ([O’Malley & Valdez, 1996](#); [Ivy et al., 2023](#)), authentic assessment is performance-directed, simulating real-life tasks ([Wiggins, 2011](#); [Merrett, 2022](#); [Collins, 2022](#)). These authentic tasks help students understand the relevance of their work to future employment. [Andreatos \(2023\)](#) advocates for pluralism in assessments, including a variety of tests for skills, attitudes, and knowledge. The paper acknowledges the ongoing debates and varying definitions surrounding authentic assessment, and aims to address this issue by synthesizing existing literature to provide a more comprehensive understanding of the concept. Specifically, the review explores key elements and characteristics of authentic assessment as defined by various theorists and researchers, aiming to clarify its contribution to the enhancement of graduates’ 21st century skills.

[Petre \(2017\)](#) and [Al-Zoubi \(2019\)](#) highlight the importance of student responsibility and critical thinking within authentic assessment. [Boud \(2000\)](#) and [Boud and Soler \(2016\)](#) introduces sustainable assessment for long-term development and evaluative judgment ([Bearman et al., 2023](#)), supported by shifts to real-world learning ([Archer et al.,](#)

[2021](#)). [Fergusson et al. \(2022\)](#) link authentic assessment with work-based learning, while [Schultz et al. \(2022\)](#) connect it with lifelong learning and sustainability awareness.

From a societal perspective, [Forsyth and Evans \(2019\)](#) and [Vu and Dall’Alba \(2014\)](#) suggest a broader approach to authentic assessment, focusing on holistic student development. [McArthur \(2023\)](#) critiques traditional authenticity, urging a focus on social justice and societal transformation. [Ajjawi et al. \(2023\)](#) advocate for preparing graduates for a transforming world without neglecting workplace realities.

This study argues for a broader definition of authentic assessment, centered on students and their communities, and acknowledges the shift to online platforms after the COVID-19 pandemic restrictions ([Butler-Henderson & Crawford, 2020](#); [Kaisar, 2023](#)). It advocates using “authentic assessment” and “alternative assessment” interchangeably, acknowledging authentic assessment as one of the approaches in alternative assessment ([Aziz et al., 2020](#)) with emphasis on innovative, student-centered pedagogies that equip graduates for professional integration and competitiveness. However, the authors understand that alternative assessment encompasses a broader range of non-traditional assessment methods that may not necessarily be linked to professional or workplace environments. Nonetheless, the term “alternative assessment” was included in the search to ensure a comprehensive review and to avoid missing any critical studies that might contribute valuable insights into the practice and implementation of authentic assessment.

## 3. Framing the rationale of the present study

In the preliminary phase, the authors reviewed literature, conceptual papers, and reflective essays on authentic assessment in higher education to identify research gaps and establish the context of the study. Early contributions, such as those by [Vu and Dall’Alba \(2014\)](#), emphasize the ontological significance of authentic assessment in student development. This perspective is supported by [Lean and Barber \(2022\)](#), who advocate for broader, holistic views beyond mere professional relevance, considering Vu and Dall’Alba’s work. [Griffith \(2023\)](#) discusses the post-COVID-19 shift towards dynamic, online assessment methods, focusing on critical skills relevant to professional settings. [Lim, Gottipati, et al. \(2022\)](#) analyze immersive and adaptive learning technologies in assessment, noting challenges in technology maturity and ethical concerns. Recent literature ([Hossein Arefian, 2023](#); [Kaisar, 2023](#)) calls for a more student-centered approach to online learning, teaching, and assessment.

[Raynault et al. \(2022\)](#) advocate for using digital technologies to create engaging and meaningful assessments. [Nieminen et al. \(2023\)](#) critique current assessment practices for lacking emphasis on critical digital literacy. [Heil and Ifenthaler \(2023\)](#) review online assessment modes, highlighting their effectiveness in improving learning outcomes, emphasizing the importance of instructional support and transparent criteria ([Mohamed & Lebar, 2017](#)). [Loureiro and Gomes \(2022\)](#) and [Zhang, Zhang, and Liu \(2021\)](#) discuss the impact of online peer assessment on enhancing student learning and skills relevant to real-life applications, with peer assessment identified as an effective strategy to stimulate student performance and develop key professional skills ([Atifnigar et al., 2020](#)).

Researchers have aligned authentic assessment tasks with professional life, emphasizing employability and authenticity ([Sokhanvar, Salehi, & Sokhanvar, 2021](#)). Positive perceptions of authentic assessment are supported by [Atifnigar et al. \(2020\)](#). [Villarroel et al. \(2018\)](#) highlight three core dimensions of authentic assessments: realism, cognitive knowledge, and evaluative judgment, proposing a four-stage model that considers workplace context and provides formative, summative, and sustainable feedback.

Other literature reviews focus on specific disciplines. [Maude et al. \(2021\)](#) reviewed authentic learning principles in nursing education, identifying themes like clinical practice, self-assessment, and simulations. [Bayley \(2023\)](#) noted positive perceptions of authentic assessment

in healthcare education. [Monib et al. \(2020\)](#) observed positive effects of authentic assessment in English as Foreign Language (EFL) classrooms. [Sundari \(2023\)](#) compared four types of authentic assessment in English language teaching, highlighting their effectiveness in promoting cognitive skills and real-world application. [Mansory \(2020\)](#) stressed the importance of authentic assessment in developing reflective skills. [Suwartono and Riyani \(2019\)](#) emphasized the need for authentic assessment in addressing cognitive, psychomotor, and affective domains. [Nkhoma et al. \(2018\)](#) reviewed authentic assessment in accounting courses, highlighting its role in developing essential skills and emphasizing the design of comprehensive rubrics ([Nkhoma et al., 2020](#)). [Ghosh et al. \(2017\)](#) discussed authentic assessment in seafarer education, presenting a conceptual framework emphasizing validity and reliability aspects.

Despite the growing body of literature on authentic assessment in higher education, there remains a notable gap in research that specifically examines how these practices contribute to the development of essential 21st-century skills, including critical thinking, problem-solving, communication, and collaboration. While many studies highlight the general benefits of authentic assessment, few focus on the empirical outcomes of these practices in cultivating skills that are increasingly valued in the modern workforce. This will happen in this systematic review through the analysis of empirical studies, conceptual papers and reviews that directly examine the relationship between authentic assessment and these specific skills. The analysis of the findings provides information about how universities may better design and

develop assessments aligned with the changing demands of both the labor market and the students. This review puts emphasis on both in-person and online authentic assessment across a wide range of disciplines, distinguishing itself from earlier studies. While hybrid models may offer valuable insights, they were excluded to maintain a focused scope and to ensure a detailed examination of the unique challenges and opportunities associated with purely face-to-face and fully online contexts. The practical and policy implications of incorporating authentic assessment into higher education curricula are discussed in detail to mobilize further research.

#### 4. Materials and methodological approach

To minimize potential bias, a predefined review protocol was organized. The literature review was conducted between November 2023 and February 2024, following specific design stages. A systematic review of relevant studies published from 2014 to 2024 was performed using the following electronic databases: Web of Science, Scopus, ERIC, Taylor and Francis, Springer, Wiley, and Google Scholar. Comprehensive literature reviews help identify knowledge gaps, introduce theoretical frameworks, develop conceptual frameworks, discuss key findings, develop research ideas, and evaluate research outcomes ([Sajeevanie, 2021](#)). These reviews are crucial for delineating the current research landscape, aggregating pertinent studies, offering detailed examinations, critiquing contributions, assessing methodological frameworks, and suggesting future inquiries.

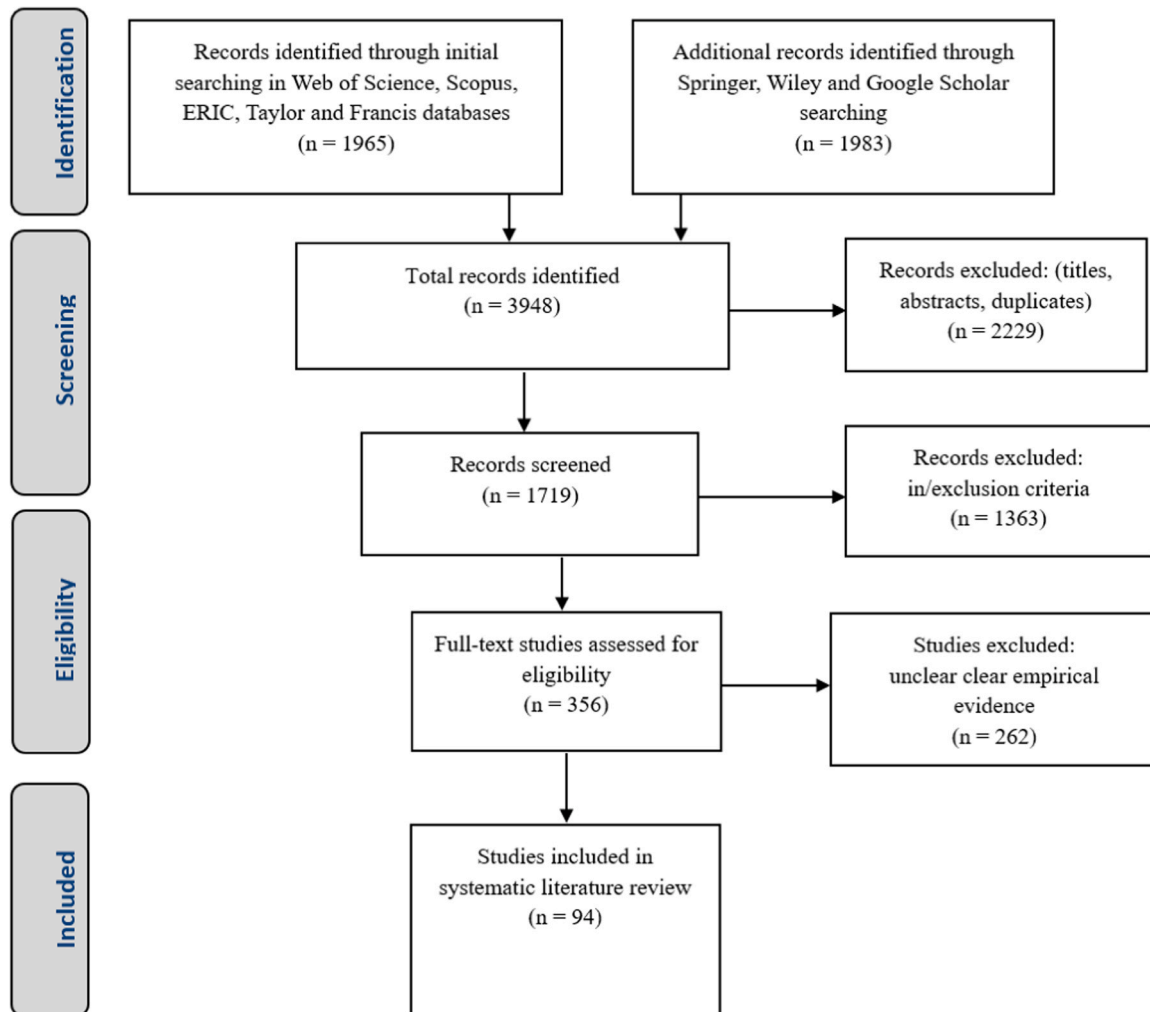


Fig. 1. Flow diagram illustrating the literature review selection process.

This review concentrates on the past decade, noting to a surge in publications, especially after the COVID-19 pandemic, due to disruptions in traditional examinations and the challenges associated with in-person assessments. The PRISMA model (Moher et al., 2015; Page et al., 2021) was applied, comprising: (i) search strategy, (ii) selection, (iii) quality assessment, (iv) data extraction, and (v) data synthesis (see Fig. 1).

The first phase (search strategy) used search engines like Google and ResearchGate to search for "authentic assessment," identifying synonymous terms as depicted in Table 1.

This phase provides an overview of the current state-of-the-art and helps experts draw a framework for systematic research (Linnenluecke et al., 2020). "Authentic assessment" and "alternative assessment" were the most frequently used terms. The search string employed was: "authentic assessment" OR "alternative assessment" OR "performance assessment" AND "effects" OR "impact" AND "higher education." The search focused on abstracts rather than keywords for accuracy. A total of 1965 records were identified from Web of Science, Scopus, ERIC, and Taylor and Francis, and 1983 records from Springer, Wiley, and Google Scholar, totaling 3948 records (see Fig. 1).

In the second phase (selection), the two researchers independently screened the titles, abstracts, and duplicates of the 3948 publications. A total of 2229 papers were excluded, and the remaining 1719 articles were reviewed for further information. The primary focus was on examining the application of authentic assessment in higher education institutions in relation to the development of critical 21st century skills. Several inclusion and exclusion criteria were established to filter out non-relevant articles, ensuring transparency and reproducibility of the selection results (see Table 2).

Upon review, documents irrelevant to the study's focus or failing to meet predetermined criteria were discarded, excluding 1363 papers. Subsequently, 356 full-text articles were analyzed for empirical methodological evidence clarity. The authors independently conducted a thematic analysis, reviewing each article multiple times to understand its focus, theoretical framework, methodology, themes, and key findings, leading to the exclusion of 262 studies lacking clear empirical evidence on authentic assessment methods in higher education.

In the third phase, the data set's quality was evaluated concerning the implementation of authentic assessment in face-to-face or online educational settings for the development of key 21st century skills. This assessment refined the data set to 94 documents, analyzed to aggregate data pertinent to the review's aims and research questions. Of those 94 papers, 67 were empirical studies that directly addressed the research questions by providing data on how authentic assessment methods enhance the development of 21st-century skills and the reported outcomes across different stakeholders. These studies formed the basis of the results section (Section 5). The remaining 27 non-empirical studies were included to reinforce and support this study, providing valuable theoretical insights. They helped position the research questions within the broader landscape of authentic assessment literature, emphasizing its role in developing 21st-century skills and identifying key challenges and debates. Specifically, these conceptual papers helped clarify the definition and scope of authentic assessment, offering essential context for understanding its impact in higher education. Thematic analysis, with a qualitative-based orientation, was conducted to illustrate the

**Table 1**  
Key concepts and closely related concepts.

Key concepts	Closely related concepts
Authentic assessment	Alternative assessment, performance assessment, performance-based assessment, sustainable assessment, descriptive assessment, informal assessment, direct assessment, process assessment, process evaluation, criterion-referenced assessment, dynamic assessment, formative assessment

**Table 2**  
Inclusion and exclusion criteria.

	Inclusion criteria	Exclusion criteria
Study design	Empirical studies (qualitative research, quantitative research, experimental, quasi-experimental, case studies, observational studies, mixed-methods research), meta-analyses, reflective papers, systematic literature reviews	Non-empirical studies, reports, editorials, thesis, doctoral dissertations
Publication date	Articles published between the years 2014–2024	Articles published before 2014
Participants	Aged over 18 (students, adult learners)	Ages younger than 18
Type of selected articles	Journal articles, book chapters, conference papers	Books, editorials, book reviews, theses, dissertations
Written language	English	All other languages
Delivery mode	Face-to-face, online education	Hybrid model of education
Research themes	Authentic assessment, alternative assessment, employability, authenticity, digital technologies	No reference to forms of authentic assessment, alternative assessment
Education level	Higher education	All other forms of education (Pre-primary education, primary education, secondary education, vocational education, adult education)

concepts and definitions of the authentic assessment from different perspectives (Clarke & Braun, 2017; Herzog et al., 2019; Naeem et al., 2023). At a theoretical level, the result of such an interpretative process was to obtain valuable ideas and make specific proposals on how authentic assessments can be utilized especially in the post-pandemic context for the development of 21st century skills, and how such assessment methods could inform future research. At the methodological level, we first portrayed the profile of the peer-reviewed articles through descriptive findings and characteristics of the dataset, such as participants in the target-group, year of publication of the peer-reviewed papers, geographical distribution of regions or countries where the studies were performed, methodological approach, among other aspects. The thematic analysis then led to certain themes. It is important to emphasize that no intentional bias influenced the selection of studies, and the concentration of research in Australian regions reflects the natural outcome of the selection process. Overall, there is a growing global interest in using authentic assessments to evaluate student progress, particularly in fostering essential 21st-century skills such as critical thinking, collaboration, and problem-solving—skills crucial for both future employability and personal development. This trend is reflected in the publication timeline of the 94 selected papers, as presented in Section 5.1.

## 5. Results and discussion

This first section portrays the profile of the reviewed papers, in regards to distribution by years, types of articles, geographical distribution, samples, discipline areas, and research methodology used in the selected articles.

### 5.1. Profile of the reviewed articles

The publication timeline of the selected 94 papers shows that only one paper was published in 2014, two in 2015, two in 2016, six in 2017, eight in 2018, five in 2019, eleven in 2020, eleven in 2021, 21 in 2022, and 26 in 2023. Additionally, by February 2024, one paper had already been published, confirming the upward trend of using authentic

assessments to evaluate student progress, particularly in fostering essential 21st-century skills. Concerning the participants involved in the 67 empirical studies, in total there are seven thousand, one hundred and forty-three (n=7.143) respondents, which is deemed as a large-sized grouping. Among them, five thousand, six hundred thirty-nine (n=5.639) are either under-graduate, graduate, or post-graduate students, and varied from four (n=4) to one thousand, one hundred and seventy-six (n=1.176). Also, one thousand, five hundred and four participants (n=1.504) are either lecturers, or faculty members, and varied from three (n=3) to two hundred and ninety-six (n=296) participants.

Of the 67 empirical studies, most were qualitative (n=23), utilizing case study methodology, semi-structured interviews, and focus group discussions. Other qualitative methods included written reflections, observations, data analytics from Learning Management Systems (LMS), online chats, and document analysis. Twenty studies used quantitative methods, employing questionnaires or online surveys, experimental factorial designs, quasi-experimental designs, action research designs, and scenario-based designs. Twenty-two studies used a mixed-method approach, combining Likert-scale questionnaires and opinion surveys with open-ended or semi-structured interviews or focus group interviews. Mixed-method studies enhance the validity of conclusions through triangulation (Creswell & Poth, 2016). Only one study used a multi-phase approach to design and conduct an authentic assessment task and explore teaching staff's perceptions.

Table 3 illustrates the methodological approaches of the 67 selected empirical studies.

This variety in methodological approaches underscores the complexity and multifaceted nature of studying authentic assessments in educational contexts, as there is a need to capture both quantitative and qualitative insights for a deeper understanding of individual experiences and contextual factors. The use of different methodologies reflects the diverse aspects of authentic assessments that need to be examined, from the effectiveness and impact on learning outcomes to the perceptions and experiences of students and educators. The use of a range of research methods helps researchers address the several dimensions and variables associated with authentic assessment and provides a holistic perspective on how it functions effectively when applied in educational settings. From the total 94 papers, the vast majority was published in highly indexed international journals (n=80), followed by conference papers (n=9), and book chapters (n=5). The types of papers were empirical research (n=67), literature reviews/critical scoping reviews (n=19), theoretical/conceptual papers (n=5), reflective essays/papers (n=2), and meta-analysis/bibliometric analysis (n=1).

Geographically, most studies were conducted in Australia and New Zealand (n=22, 32.8%), followed by Asia (n=21, 31.3%). This highlights the significant contributions of Australian and Asian researchers, particularly due to Indonesia's 2013 curriculum emphasizing formative assessment (Puad & Ashton, 2023) and the requirements of Australian accreditation bodies for diverse types of assessments (TEQSA, 2022). Europe accounted for eight studies (11.9%), the Americas for six (8.9%), Africa for six (8.9%), and one study (1.5%) covered both Asia and Europe. Three studies did not mention their country of origin. The empirical studies involved a total of 7143 respondents: 5639 were undergraduate, graduate, or postgraduate students, with participant numbers ranging from 4 to 1176. Additionally, 1504 participants were

**Table 3**  
Methods used in the reviewed empirical studies.

Methods	Frequency	Percentage %
Mixed-method	22	32.8 %
Quantitative	20	29.8 %
Qualitative	23	34.3 %
Multi-phased approach	1	1.5 %
Not mentioned	1	1.5 %
Total	67	

teaching staff, with numbers ranging from 3 to 296.

Authentic assessment tasks can be applied across scientific disciplines. This type of assessment connects new knowledge, human skills, and real-life applications. The data showed that most studies (n=22) were related to Applied Science; 12 covered Human, Social, and Education Sciences; 18 focused on STEM and Healthcare Sciences; and only 2 were related to Natural Sciences. Six studies covered multiple disciplines, while 7 did not specify a content area. Additionally, 27 articles were theoretical papers and literature reviews. The distribution of empirical studies by area is shown in Table 4.

### 5.2. Authentic assessment for the development of 21st century skills

This section explores the role of authentic assessment in developing 21st-century skills. It is divided into four sub-sections, each focusing on a specific aspect of how authentic assessment can be designed and implemented to foster critical skills and enhance students' employability. Specifically, effective authentic assessment strategies across disciplines are presented, followed by insights from the literature into how authentic assessment can enhance the development of future-ready skills through the use of technology. The section concludes with a synthesis on how authentic assessment enhances students' career readiness and professional identity, while also addressing the challenges and opportunities for its successful implementation.

#### 5.2.1. Effective authentic assessment strategies for developing 21st-century skills across disciplines

The examined resources revealed a wide range of authentic assessment types, methods and techniques, largely shaped by the experience and skills of teaching staff across different disciplines. These assessments, as Sulaiman et al. (2020) found, are more frequently used by experienced teaching staff, particularly in fields such as education sciences and medicine, promoting the development of critical 21st century skills (Al Ghazo, 2023). However, according to Hains-Wesson et al. (2020), there is no consensus among teaching staff on the reforms needed to standardize authentic assessment processes, highlighting the need for clearer frameworks on how to foster critical 21st century skills through authentic, student-centered assessment. Authentic assessment requires students to apply learned skills in real-world contexts, both inside and outside the classroom. Techniques include self-assessment, peer assessment, group assessment, practical in-class assessments, written essays, group projects, field reports, portfolios, case study discussions, interviews, role-play exercises, and teacher observations (Sewagegn & Diale, 2020). These strategies enhance critical thinking and self-criticism (Ketonen et al., 2023), helping students become

**Table 4**  
Discipline areas.

Subject area	Number of studies
Applied Sciences*	22
Human/Social/Education Sciences**	12
STEM subjects***	9
Healthcare Sciences****	9
Natural Sciences*****	2
Mixed*****	6
NS*****	7
Total	67

\*Includes Management, Business Administration, Financial Administration, Accounting, Marketing, Sport Studies, Applied Statistics. \*\*Includes Literature, Language and Linguistics, Philosophy, Psychology, Sociology, Social Welfare and Justice, Criminology and Law. \*\*\*Includes Science, Technology, Engineering, Mathematics, Robotics, Technology and Marketing, Computer Engineering, and Digital Electronics. \*\*\*\*Includes Medicine, Nursery, Pharmacy, and Midwifery. \*\*\*\*\*Includes Biology, Chemistry, Physics, Astronomy, and Geology). \*\*\*\*\*Studies referred to many content areas (e.g. Natural Science and Social Science, Nursing and Social Sciences, Digital Media and Medicine, Criminology/Communities and criminal Justice/Sport, Physical Activity and Health). \*\*\*\*\*Not stated.

proficient and responsible learners (van Rensburg et al., 2022), as well as professionals and citizens.

The effectiveness of authentic assessment in fostering specific skills also varies across disciplines (Nyninge, 2023). For example, Kaya and Özkan (2019) found that peer and self-assessment in literature and linguistics fostered collaboration, interaction, and self-confidence among pre-service language teachers. However, an intense focus on assessment scoring can place undue emphasis on the product rather than the learning process. To address this, teaching staff can use assessments as learning opportunities to bridge the gap between theory and practice, highlighting authentic assessment's adaptability to disciplinary needs. This approach not only builds student confidence (Thurab-Nkhosi et al., 2018; Wiewiora & Kowalkiewicz, 2019), but also prepares them for the labor market.

In nursing education, it was found that authentic assessment improves student confidence, knowledge, motivation, and skill competencies (Wu et al., 2015; Chong et al., 2016). Authentic assessments promote employability and student satisfaction by enhancing attitudes and behavioral intentions (James & Casidy, 2018). Collins (2022) found that students enjoyed authentic assessments, which deepened their subject knowledge and application to real-life tasks and nursing students' practical skills were enhanced through authentic assessments (Chong et al., 2016).

Moreover, in the professional field of law, assessments include preparing for client meetings and court cases (Collins, 2022), mimicking the real-world challenges lawyers face in their careers. Similarly, in pharmacy, authentic assessments involve patient interviews or counseling simulations (Ivy et al., 2023), allowing students to apply their knowledge in real-life situations. and develop crucial skills such as communication, decision-making, and empathy, which are essential for successful patient care. In business, management and healthcare education, project-based learning and rubrics are common to enhance critical thinking and creativity (Chong et al., 2016; Chong et al., 2020; Colthorpe et al., 2021; Montano et al., 2023), through students engagement in real-world problem-solving scenarios. Group work and presentations are emphasized in healthcare and hospitality courses for their collaborative nature (Carter et al., 2015; Maniram & Maistry, 2018), mirroring the interpersonal dynamics required in professional settings. Applied business courses, such as logistics and supply chain management, use multi-dimensional authentic assessments like visual posters and video presentations, both online and face-to-face (Nkhoma & Nkhoma, 2019; Akbari et al., 2022), which contribute to the development of digital literacy, collaboration, and problem-solving, all of which are essential for employability in these fast-evolving fields. Reflective exercises in business foster cognitive and new planning skills, through project-based assessments (Wright, 2023), which are vital for effective decision-making and leadership in business environments. Authentic assessment also encourages active learning, collaboration, and peer feedback, crucial for the leaders of tomorrow (Carter et al., 2015; Villarroel et al., 2018; Dawson et al., 2021). Simulation in marketing education has been proved to provide reflection, feedback, and real-world comprehension, though students may not always see the transferability of skills to other domains (Farrell, 2020; Ashford-Rowe et al., 2014).

### 5.2.2. Integrating technology in authentic assessments for future-ready skills

The rapid shift to online assessments, driven by technological advancements and the COVID-19 pandemic, has led to a significant increase in the adoption of online assessment methods. This transition has enhanced the flexibility, accessibility and industrial relevance of these methods (Lim & Lim, 2023). Online assessments, as defined by Allan (2020), are assessments mediated by digital technology and can be delivered securely, either synchronously or asynchronously. Given that students are digital residents (Connaway et al., 2011), they showed a preference for computerized assessments during the COVID-19

pandemic (Al-Sabbah et al., 2022). Teaching staff demonstrated similar preferences, since they found this type of assignments more objective and faster to evaluate (Al-Sabbah et al., 2022), raising concerns about over-reliance on easily gradable tasks at the expense of more complex, skill-oriented assessments. In the same line, Bearman et al. (2023), reflects on the dilemma of choosing between frequent, lower-quality assessments focused on compliance and accreditation (quantity) and deeper, more meaningful assessments like digital portfolios (quality).

One of the key outcomes of using online authentic assessments is their association with sustainability and societal relevance. Wakefield et al. (2023) found that digital assessments aligned with the UN Sustainable Development Goals (United Nations, 2018) can address global problems, supporting McArthur's (2023) view that authentic assessment promotes positive societal change, while fostering crucial career skills such as environmental awareness and collaborative problem-solving. Such assessments prepare students for sustainability challenges by fostering engagement and relevant career skills (Asgarova et al., 2023). Techniques include case analyses, problem-solving activities, and digital simulations, all of which promote the development of 21st-century skills (Ajjawi et al., 2020).

Teaching staff and administrators have reported varying preferences for online assessment types, with quizzes and online projects being most popular for their ease of management and for their suitability in promoting practical skills (Gaikwad et al., 2023). However, interactive oral examinations and online simulations have been proven to significantly enhance communication, effectiveness in developing employability skills, and professional identity. Tools like Online Reader's Theatre (ORT) have been shown to foster creativity and collaboration in assessments (Nugent, 2021; Bakar & Sulaiman, 2023). Additionally, these types of online assessments are considered effective in reducing academic dishonesty, particularly among younger students who are more prone to cheating and often collaborate with peers during extended assessments (Sotiriadou et al., 2020; Way et al., 2021; Tan et al., 2022; Adama et al., 2023).

The versatility of online authentic assessments is further demonstrated in the use of learner-generated content. Replacing essays with learner-generated podcasts can develop real-world skills and increase student satisfaction (Wakefield et al., 2023). Similarly, designing e-book projects motivates students to become self-publishers and self-directed learners, enhancing their responsibility, autonomy, and 21st-century skills. Other commonly used synchronous and asynchronous online assessments include written tests, discussions, projects, and portfolios, which improve learning outcomes and engagement (Sutadji, Susilo, Wibawa, Jabari, Rohmad 2021a, 2021b; Bearman et al., 2023). The value of e-portfolios, in particular, has been recognized by several authors as a "well-organized, visually appealing record of their academic and professional knowledge, skills, and attributes" (White, 2019, p.4).

From the perspective of students, these assessments contribute to their personal and professional growth by offering opportunities for self-reflection and intrinsic motivation. The use of digital tools and innovative assessment practices leads to the development of key professional skills, such as digital skills and critical thinking (Hussain & Al Saaidi, 2019). An illustrative example is the GHMA assessment design, which promotes self-reflection and intrinsic motivation by combining gamification, heutagogy, and multimodal assessments (Lim et al., 2022a, 2022b; Lim et al., 2023a, 2023b). This assessment design enables learners to set their own goals and use feedback from learning analytics for the creation of personalized multimodal artifacts that reflect their growth. This type of gamified assessment is linked to the development of self-reflection, self-esteem, self-efficacy, and intrinsic motivation through engaging interactions with the learning platform. According to Chong et al. (2020) the use of rubrics on an Learning Management System (LMS) as guiding and feedback tools, helps students utilize cyclical self-regulated learning strategies. The authors also note that the ability of the LMS to track student progress and facilitate access to

feedback is crucial, especially in online education, since this can compensate for the lack of face-to-face interaction and maintain student engagement. Despite some opposition, online discussion forums have also been proven to support self-regulated learning (Chong et al., 2020). Overall, digital assessments significantly enhance students' employability, through the development of key competencies, such as adaptability, problem-solving, and digital literacy.

However, challenges such as academic integrity and professional accreditation for invigilated assessments persist (Holden et al., 2021). Huber et al. (2024) emphasize the necessity of remote online invigilation to maintain course validity and meet accreditation requirements. The International Center for Academic Integrity outlines six core values: honesty, trust, fairness, respect, responsibility, and courage (International Center for Academic Integrity, 2021). Literature suggests that academic integrity is often undermined by flawed assessment design and insufficient instructor surveillance (Shikwaya & Amadhila, 2023; Huber et al., 2024). Additionally, the use of AI tools like ChatGPT has increased academic misconduct, although these tools can also enhance learning (Sullivan et al., 2023; Hua, 2023; Oravec, 2023; Essel et al., 2024). Maintaining academic integrity is of utmost importance not only for the credibility of universities but also for ensuring that students acquire critical skills for their professional life, as employers seek graduates with a strong ethical foundation and the ability to apply their knowledge responsibly in professional settings. To address these issues, strategies include creating different questions for individual students, requiring online presentations for submissions, combining various assessment methods, designing assessments specifically for remote delivery, incorporating new technologies, ensuring fair and secure assessment processes, and utilizing e-proctoring software for remote invigilation (Stavride & Kokkinaki, 2023; Shikwaya & Amadhila, 2023; Kaisar, 2023).

### 5.2.3. Authentic assessment for enhancing students' career readiness and professional identity

One key characteristic of authentic assessment is its ability to develop employability skills relevant to real-life practices. For this study, employability is defined as the ability to find, create, and sustain meaningful work across one's career lifespan, encompassing the knowledge, skills, attitudes, and personal attributes that make a person more likely to choose and secure satisfying and successful occupations (Villarroel et al., 2021). This requires students to develop metacognitive capacities applicable to their professional lives. For instance, O'Keeffe (2020) demonstrated that social work course assessments simulate real-world activities, encouraging students to act as social agents.

Prospective employers often criticize graduates for lacking strategic planning, coping skills, and the ability to work under pressure (James & Casidy, 2018). Römgens et al. (2020) describe employability through a multi-dimensional, competence-based approach, which includes disciplinary knowledge, generic skills, social and networking skills, lifelong learning, adaptability, and metacognitive skills. In this context, authentic assessment fosters lifelong learning and employability, benefiting both students and academic institutions (Donald et al., 2020).

The focus on employability is particularly strong in business and management curricula, as universities aim to produce graduates who are ready for the workforce and capable of collaborating with employers (James & Casidy, 2018; Manville et al., 2022). Incorporating authentic assessment into business curricula is advantageous because it involves tasks that reflect professional practice rather than merely assessing memorization (Scott & Unsworth, 2018), offering values that go beyond mere academic achievement (Lim, 2022). This approach helps learners adapt to the evolving workplace (Thurab-Nkhosi et al., 2018). Notably, Pallant, Pallant, and Jopp (2022) found that client-based projects (CBPs) can negatively impact undergraduate student satisfaction but have positive effects at the postgraduate level when implemented effectively. Journalism students appreciate these assessments but may lack confidence in sharing their work (Fulton et al., 2021).

Problem-solving scenarios and critical thinking tasks also enhance employability skills (Connolly et al., 2023).

While most universities show preference to summative assessments, it is important to mention that authentic assessments are often used as formative assessments to support students achieve the intended learning outcomes (Nyinge, 2022). The fact that higher education institutions still rely on summative assessments may be due to a lack of awareness of the benefits of formative assessments or a tradition of using conventional methods (Sulaiman et al., 2020). Even though there is evidence that authentic assessment enhances learning, an important part of the teaching staff may still use traditional assessment methods, which may not contribute as much to students' skills development (Sewagegn & Diale, 2020). In this context, it is important to design authentic assessment that aligns with the demands of the industry in order to help students create and establish their professional identity (Ajjawi et al., 2020). Whittam's (2023) study provides further evidence that authentic assignments help students develop practical experience and employability skills, preparing them for future careers. In this same line, Davidson et al. (2019) argue that authentic assessment helps students become work-ready and fosters their professional identity, aiding their transition to the labor market.

### 5.2.4. Challenges and opportunities in implementing authentic assessment for 21st-Century skills development

Authentic assessment is increasingly recognized (Searle & Poth, 2021) for its role in developing employability skills relevant to real-life practices, such as planning, teamwork, and critical thinking. Similarly, Binkley et al. (2012), approach authentic assessment as a way to develop skills necessary to adapt to new life and work conditions. These skills are categorized into four areas: thinking (creativity, critical thinking, problem-solving, metacognition), working (communication, collaboration), tools (information and digital literacy), and living (citizenship, career, personal and social responsibility). Universities must align with societal needs to cultivate these 21st-century skills. Moreover, authentic assessment encourages deeper reflection and demonstrates progress, ultimately aiding successful labor market entry (Vargas-Mendoza et al., 2018; Archer et al., 2021). Its effectiveness varies by discipline. For instance, engineering courses incorporate project-based learning and peer assessment to develop lifelong learning skills (Pang & Kootsookos, 2021), whereas social sciences often use non-exam formats and performance tests (Sutandji et al., 2021). In addition, authentic assessments are crucial for developing higher-order thinking skills and real-world practices (Kashef & Townsley, 2023). They foster the development of essential skills and human capital for real-world work settings (James & Casidy, 2018), preparing students to become capable professionals and responsible citizens who will be addressing complex, contextualized problems (Villarroel et al., 2020). For example, Lisdawati and Umam (2022) found that authentic assessment promotes creativity, context analysis, source evaluation, and solution finding tailored to student needs. Similarly, Fergusson et al. (2022) demonstrated the relationship between authentic assessment and work-based learning in fostering lifelong learning and professional identity. Critical 21st century skills, such as critical thinking, creativity, communication, collaboration, and problem-solving, are crucial for student success (Juanda, 2022; Connolly et al., 2023). Developing these skills requires both subject-matter knowledge and transversal skills like creativity and teamwork (Guzzoni et al., 2017). Case study-based projects, for example, enhance performance, knowledge transfer, and peer collaboration compared to traditional projects (Merrett, 2022). Leadership skills can be developed through reflective authentic tasks. Wiewiora and Kowalkiewicz (2019) found that authentic assessment enhances students' leadership skills, self-efficacy, and self-concept, preparing them to become effective leaders. Innovation skills are also essential; Keinänen et al. (2018) concluded that authentic assessments foster creative problem-solving, goal orientation, teamwork, and networking skills. Similarly, Darma (2017) found that problem-based authentic assessments improve

mathematical understanding and problem-solving skills.

Despite these opportunities, authentic assessment in higher education presents significant challenges. Teaching staff often lack the necessary experience to design effective authentic assessments (Brown et al., 2022), and face constraints such as limited standardized measures, time pressure, diverse student needs, and adapting rubrics to new assessment types (Juanda, 2022). Moreover, the heavy workload and extensive preparation required for authentic assessments can be overwhelming (Thurab-Nkhosi et al., 2018). Inadequate preparation may also negatively impact the quality of achievement (Villarroel et al., 2020). Designing authentic assessment tasks is particularly challenging due to diverse career paths and traditional scoring systems that focus on content knowledge rather than transferable skills (Schultz et al., 2022; Al-Sabbah et al., 2022). Islam and Ahmed (2018) highlighted that the large number of students assigned to each teacher is an additional challenge for the effective implementation of authentic assessments. Furthermore, students often experience anxiety and tension when participating in authentic assessments, especially when working in teams (Maniram & Maistry, 2018). Students have also reported insufficient teacher support and monotonous types of the assessment (Kong & Yuen, 2022). Finally, Gaikwad et al. (2023) found that an important number of teaching staff demonstrate moderate assessment literacy, which impacts negatively their ability to design and develop authentic assessments effectively. Yan and Pastore (2022) confirm the low levels of assessment literacy and a lack of theory-driven tools, underscoring the need for training in assessment instruments and strategies.

In response to the two research questions of the study, the findings reveal that methods such as case studies, project and problem-based learning and simulations are mostly associated with the development of 21st century skills, such as critical thinking, problem-solving, teamwork and communication across various disciplines. In terms of the challenges and opportunities for implementing authentic assessments in university education, the study identifies limited assessment literacy among teaching staff, high preparation demands and lack of support mechanisms, which may lead to monotonous assessment types. At the same time, significant opportunities are highlighted, such as the alignment of assessment practices with industry needs to enhance employability and responsible citizenship. This systematic review underscores the dual potential and complexity of implementing authentic assessment in higher education and points to areas where further support and innovation are needed to maximize its impact on student experience and readiness for the labor market and the evolving societal needs.

## 6. Limitations, practical and policy implications and recommendations

### 6.1. Limitations and future agenda

Interest in authentic assessment in higher education has surged, underscoring its global research momentum. However, the coverage in European and African contexts remains limited. This warrants further investigation into the applicability and effectiveness of authentic assessment in these regions.

This study utilized the PRISMA method for literature review but encountered some limitations. Potential biases arising from database selection and search strategies may have led to the omission of relevant studies. To mitigate these biases, future research should incorporate a broader range of search engines and databases, such as Academic Search Premier (EBSCO) and ProQuest, and include non-English publications. Additionally, expanding the search to encompass theses, dissertations, and official reports is recommended to achieve a comprehensive literature capture, especially when measuring the development of 21st-century skills across various educational contexts. Another limitation was the frequent omission of key details, such as demographic information and methodology, in many reviewed studies, which impacts the validity of the findings. A focus on empirical studies that clearly report on

methodologies and provide demographic information is recommended to enhance the reliability of findings.

Future research should extend the scope beyond higher education to include K-12, secondary, vocational, and adult education to enhance comparability. While the review process was thoroughly justified from its theoretical foundations to its methodology to ensure reliability and consistency, a quantitative meta-analysis was not conducted due to time constraints. Therefore, the use of bibliometric analysis is suggested for a more detailed examination of the data (Donthu et al., 2021).

Future research could extend this work by specifically exploring hybrid models to provide a more comprehensive understanding of how authentic assessment can be effectively integrated in such learning environments.

Most of the reviewed studies relied on self-reported student outcomes, which may not accurately reflect true knowledge acquisition or skill development. To effectively measure the development of 21st-century skills, future studies should adopt quasi-experimental designs with external performance measurements and consider multiple data sources, including field observations and learning analytics, for a more accurate assessment of student learning. To evaluate skills effectively, authentic assessment practices such as performance tasks, project-based assessments, product evaluations, and portfolios are recommended (Yustitia & Wardani, 2017). This approach will provide more evidence on how authentic assessment fosters employability skills and facilitates stakeholder engagement in the educational process.

### 6.2. Practical implications and policy considerations

Implementing authentic assessment in universities is challenging due to the reluctance of teaching staff to shift from traditional methods like closed-book tests and oral exams. Recent literature underscores the value of authentic assessment for fostering the development of essential 21st-century skills. To this end, integrating authentic assessment methods into national curricula is essential for preparing students for real-world applications and equipping them with the skills required for professional success. This transition requires professional development and support for teaching staff to effectively design and implement authentic assessments that align with both institutional goals and industry demands.

The QAA (2017) endorses authentic assessment as a means to address cheating and ensure academic integrity by emphasizing the design of well-developed, realistic, and challenging assessments. These assessments, informed by recent literature, have the potential to enhance students' understanding, knowledge achievement, satisfaction, and engagement. To prepare students for these new assessment types, clear instructions, guidance, appropriate resources, and emotional support from teaching staff are needed. As research suggests (Murphy et al., 2017; Barker, 2022; Kong & Yuen, 2022; Akbari et al., 2022) teaching staff must provide explicit guidelines and constructive feedback to help students manage any anxiety associated with transitioning to more complex forms of assessment. University teaching staff require systematic guidance in order to develop the necessary skills to design and implement authentic assessments confidently and Sulaiman et al. (2020) recommend improving their literacy in terms of both assessment and digital skills. As online assessment methods gain traction, it is essential to develop teaching staff's digital skills to design online assessments and leverage technology-based multimedia (Ibrahim et al., 2023).

Further research is required to explore the relationship between authentic assessment and sustainable development in education, particularly in alignment with the United Nations 2030 Agenda's Sustainable Development Goals (UNESCO, 2019; Schultz et al. (2022)). University teaching staff should be offered additional training on assessment design to transition from conventional to authentic assessment strategies that promote sustainable behaviors and 21st-century skills.

Authentic assessments should be aligned with higher-order learning



outcomes, helping students understand assessment criteria and quality standards. Designing curricula and policies that offer clear feedback guidelines is crucial to shifting the assessment culture away from traditional scoring towards authentic assessment (Montano et al., 2023). Students from diverse backgrounds and disciplines benefit from prompt, constructive feedback, which fosters self-confidence and responsibility. Providing multiple opportunities for dialogue, reflection, and peer assessment enhances students' abilities to self-evaluate and improve 21st-century skills like communication, critical thinking and teamwork.

As AI technologies continue to rise, higher education institutions must address concerns regarding academic assessment integrity, incorporating safeguards to ensure that assessments remain relevant and rigorous in the digital age (Essel et al., 2024). Digital technology can support peer interaction and group work through gamified mechanisms (Wood et al., 2013). The European Association for Quality Assurance in Higher Education emphasizes e-learning assessment standards, including authentication, authorship, and exam security (Huertas et al., 2018).

To minimize academic misconduct, measures such as time-restricted authentic assessments, presentations and defense of the assessments by the students, ethical value promotion, and plagiarism detection tools are recommended (Adama et al., 2023). Higher education institutions must assess the quality standards of assessment methods to ensure they meet student satisfaction, real-world relevance, and 21st-century skills (Noaman et al., 2017).

External stakeholders should collaborate with universities to revise and reform authentic assessment methods, replacing traditional exams. Embedding authentic assessment in curricula requires a pragmatic approach, as recommended by Manville et al. (2022). Aligning assessments with course objectives ensures they accurately measure knowledge, skills and attitudes, necessitating communication with employers and industry supervisors (Al-Ghazo, 2023).

Communication among teaching staff working on authentic assessments is crucial. Technological advances accelerated by the pandemic require students to be familiar with digital equipment and consistent with obligations and schedules. Institutions should provide flexible solutions incorporating digital and blended elements in targeted assessments.

In the post-COVID era and with the rise of AI, radical transformations in national curricula are needed to meet accreditation and quality standards. A culture of participation and shared responsibility in the assessment process is essential to ensuring integrity and addressing ethical issues in authentic assessment (Lucander & Christersson, 2020). Clear and coherent policies and procedures should guide the implementation of authentic assessments, ensuring they foster student learning and 21st-century skills, ultimately preparing graduate students for the complexities of the modern workforce.

## 7. Conclusion

This systematic literature review highlights a significant challenge in higher education: the need to identify robust assessment mechanisms that mirror real-world situations and effectively measure the development of 21st-century skills. The cultural shift from traditional summative assessments, such as written assignments and standardized tests, to more innovative, holistic approaches signals a critical transition in higher education assessment practices, underscoring the importance of integrating learning-focused assessments that balance traditional methods with innovative strategies. In this context, this review contributes to the conceptual clarity of the term authentic assessment through a synthesis of diverse perspectives from the literature and the identification of its essential characteristics. Authentic assessment appears to encompass not only the use of real-world tasks but also the intentional development of critical 21st-century skills such as problem-solving, collaboration, and adaptability. These core elements, together with the distinct opportunities and challenges for implementation, offer

a deeper understanding of role that authentic assessment plays in aligning learning outcomes with the evolving needs of the labor market and the society. Despite the fact that authentic assessment has gained substantial interest among researchers and practitioners, the examined literature revealed that much work remains in terms of aligning these assessments with the practical demands of professional life and the broader societal transformations taking place. As research continues to evolve, new challenges arise for teaching staff, practitioners, and higher education leaders—particularly around the effective implementation of authentic assessments that reliably measure 21st-century skills. This study underscores the need for an alignment between the design of authentic assessments and their role in societal transformation, emphasizing that assessment practices should contribute to more than just academic achievement; they should actively shape students' ability to navigate complex, real-world environments.

Good practices for the design and implementation of authentic assessments in university education have been also identified. These include aligning assessments with learning outcomes, creating assessments that reflect real-world tasks, using multiple assessment methods for comprehensive evaluation, providing clear instructions and constructive feedback, and continuously reflecting on and improving the assessment process. The above-mentioned practices illustrate how authentic assessments bridge the gap between content retention and practical application of knowledge skills and attitudes.

One of the key findings of this review is the difference in how authentic assessments are implemented in online versus face-to-face education. In face-to-face education, authentic assessments often involve hands-on, collaborative tasks, such as group projects, in-class presentations, and real-life simulations. The physical presence of teaching staff and students facilitates immediate feedback and fosters a rich, interactive learning environment. Conversely, in online education, digital tools and platforms, such as e-portfolios and virtual simulations, provide flexibility and accessibility, allowing students to engage with assessments at their own pace and from various locations. While both modalities aim to enhance students' real-world skills and employability, the impact and effectiveness of authentic assessment vary depending on the mode of delivery. This discrepancy raises critical questions about the comparability of skill development in different learning environments, a topic ripe for future research.

This systematic review also brings attention to the ongoing debate around quantity versus quality in assessment methods. There is a clear need for more in-depth research to understand how to balance these priorities in a way that optimally supports educational outcomes and ensures the development of essential 21st-century skills (Al-Sabbah et al., 2022; Bearman et al., 2023). Moreover, the question of how authentic assessments contribute to student employability remains central to this discourse. While the review suggests that authentic assessments have the potential to enhance graduates' readiness for professional life, further empirical studies are needed to provide a more precise understanding of their impact across various educational contexts and stakeholder perspectives.

In conclusion, the shift towards authentic assessment in higher education offers promising opportunities for aligning academic skills with professional demands. However, this transition also presents complex challenges, particularly in terms of implementation, consistency, and the reliable measurement of these critical skills. Policymakers, administrators, and teaching staff must critically reflect on these findings to develop assessment strategies that not only meet current educational standards but also anticipate the evolving needs of the workforce. By adopting a reflective, collaborative, and evidence-based approach, universities can ensure that they are preparing students not just for academic success, but also for the dynamic demands of the labor market.

## Author contributions

Conceptualization, D.V.; methodology, A.M. & D.V.; validation, D.V.

& A.M.; formal analysis, A.M.; data curation, A.M.; writing—original draft preparation, A.M.; writing—review & editing, D.V.; supervision, D.V.; project administration, D.V. & A.M.

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## CRedit authorship contribution statement

**Agoritsa Makri:** Writing – original draft, Validation, Formal analysis, Data curation, Conceptualization. **Dimitrios Vlachopoulos:** Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Conceptualization.

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No conflict of interest has been reported by the authors. Both authors have read and approved the final version of the paper.

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