JURNAL UPI
Journal of Mechanical Engineering Education
(JURNAL PENDIDIKAN TEKNIK MESIN)
Available online at https://ejournal.upi.edu/index.php/jmee
(e.ISSN: 2715-4734, p.ISSN: 2356-4997)

REVOLUTIONIZING TVET ASSESSMENT: SLR FOR AN INTEGRATED FRAMEWORK FOR AUTHENTIC 4C SKILLS EVALUATION

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ABTRACT/ABSTRAK

The need for vocational education graduates to excel in 21st-century skills—critical thinking, creativity, communication, and collaboration (4C)—necessitates evaluation approaches that go beyond conventional testing. This research conducts a Systematic Literature Review (SLR) involving 13 articles published from 2014 to 2024 to examine the function of authentic assessment in measuring 4C competencies. The results emphasize four key themes: integration of technology, collective evaluation, challenges in execution, and effects on student skills. Genuine methods like e-portfolios, multimedia simulations, and teamwork projects boost student engagement and career preparedness, yet challenges persist in digital systems and reliable tools. The research highlights the necessity for industry partnerships and creativity to create forward-thinking evaluation frameworks for vocational training.

Kebutuhan lulusan pendidikan vokasi untuk unggul dalam keterampilan abad ke-21—berpikir kritis, kreativitas, komunikasi, dan kolaborasi (4C)—memerlukan pendekatan evaluasi yang melampaui pengujian konvensional. Penelitian ini melakukan Tinjauan Literatur Sistematis (SLR) yang melibatkan 13 artikel yang diterbitkan dari tahun 2014 hingga 2024 untuk mengkaji fungsi penilaian autentik dalam mengukur kompetensi 4C. Hasilnya menekankan empat tema utama: integrasi teknologi, evaluasi kolektif, tantangan dalam pelaksanaan, dan dampaknya terhadap keterampilan siswa. Metode autentik seperti e-portofolio, simulasi multimedia, dan proyek kerja sama tim meningkatkan keterlibatan siswa dan kesiapan karier, namun tantangan masih ada dalam sistem digital dan perangkat yang andal. Penelitian ini menyoroti perlunya kemitraan industri dan kreativitas untuk menciptakan kerangka kerja evaluasi yang berwawasan ke depan bagi pelatihan vokasi.

ARTICLE INFO

Article History:

Submitted/Received
09 August 2025

First Revised
15 September 2025

Accepted
10 November 2025

Online Date
13 November 2025

Publication Date
01 December 2025

Keywords:
authentic assessment, 4C skills, vocational education, systematic literature review.

Kata kunci:
penilaian autentik, keterampilan 4C, pendidikan vokasi, systematic literature review.

1. INTRODUCTION

Digitalization of industry has profoundly changed the nature of work in all corners of the world. The 21st century has seen a dramatic shift in skills demands on both ends of the spectrum, with critical thinking, creativity, creative communication and collaboration (the "4Cs") becoming indispensable for navigating today's fast-changing work environments. Automation and AI are changing all kinds of industries, and ever more human workers need these hard-to-come-by higher-order abilities. Recent data suggests that robust 65% of workers will need (Li, 2022).

The educational sector, and in particular VET, has been greatly affected by these industry changes to prepare students suitably for the workplace. Many traditional forms of assessment, that often focus primarily on documentation and theoretical knowledge recall, are unsuitable for evaluating the practical, communicative and innovative skills that are increasingly important in professional contexts. Authentic assessment has therefore been made impotent. Authentic assessments are designed to. Authentic assessments are designed to evaluate students' abilities to apply knowledge in meaningful, real-world contexts, making them ideal for assessing the 4C skills essential for success in the modern workplace (Braun & Clarke, 2019).

Authentic Assessment and Vocational Education There has indeed been substantial advancement in the integration of authentic assessment into schooling systems, especially in vocational education. However, a well-known limitation is the patchy nature of current assessment models that all too often examine discrete and decontextualized 4C competences as if they were isolated skills. According to the literature, only 23% of research combines all four 4C competences within an integrative testing design (Peter et al., 2024). Consequently, no exhaustive of comprehensive models that can assess students' abilities to employ all 4C skills simultaneously, which is essential for real-world job performance. This fragmentation limits the effectiveness of current assessment tools, which fail to reflect the holistic nature of the skills required by industry.

In addition, the extant literature tends to ignore contexts in which vocational education is taught discharging duties. The majority of research work has been carried out in industrialized nations which have very high academic facilities and resources. There is a small body of literature on how we should think about transferring the concept of authentic assessment to the developing world, to countries such as Indonesia, with its geographic inequalities and digital divides (Patel et al., 2024). In such environments, the development of authentic model may be obstructed by lack of resources (satisfactory variety and

availability of technology) or trained teachers. Thus, there is a pressing need for research that explores how authentic assessment models can be tailored to the unique conditions of vocational education systems in diverse, resource-limited environments.

The purpose of this study is to investigate the systematization of authentic assessment for the development and evaluation of 4C skills in vocational training, based on a framework which assesses critical thinking, creativity, communication and collaboration as inter-related competences. Contrary to previous research that has typically researched these skills independently, in isolation of one another, this study aims at establishing an approach that corresponds to the cooperation and interconnectedness characterizing the competencies in question within today's labor market. The project will deliver a novel formative and authentic assessment approach based on technology supported hands-on learning and context specific scaffolding of the latter so that it becomes applicable for diverse groups of vocational education students in Indonesia.

This research is novel not only for its incorporation of all four 4C competencies into a unified, comprehensive assessment framework but also for its contextual adaptation to the particular requirements of Indonesian vocational education. This research distinguishes itself from numerous studies that concentrate on Western contexts or theoretical frameworks by anchoring its findings in the tangible realities of a developing nation. The proposed model's adaptability to the challenges encountered by Indonesian vocational institutions will provide significant insights for other nations facing analogous educational and infrastructural issues (Brown et al., 2023).

2. METHOD

2.1. Methodology

This research utilizes a Systematic Literature Review (SLR) framework to explore integration of authentic assessment for 4C skills in vocational education. The SLR method was chosen due to its capacity for a comprehensive, clear, and reproducible synthesis of existing research. Through a consideration of relevant studies across a variety of sources, research hopes to identify best practice, difficulties, and gaps for implementing authentic assessment in vocational education setting. The research adopts PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) for guiding its investigation to maintain consistency and rigor across the process of a review (Page et al., 2021).

2.2. Research Questions

The primary research questions guiding this study are:

1. What are the best practices for implementing authentic assessment of 4C skills in vocational education?
2. What challenges arise when integrating 4C skills into vocational education assessment frameworks?
3. What are the impacts of authentic assessment models on the development of 4C skills in vocational education students?

These questions are central to the study, providing a clear focus for the systematic review process and guiding the analysis of the selected studies.

2.3. Sources of Information and Search Methods

The Scopus database was selected as the main data source because of its comprehensive coverage and the high standard of publications that have been subjected to international peer review (Marco et al., 2021). This choice was made with regard to its significant indexing in the area of educational and vocational research. The search approach was developed using an adapted PICO (Population, Intervention, Comparison, Outcome) framework designed for educational research contexts (Methley et al., 2014). Table 1 presents a summary of the search terms that were employed.

Table 1. Search string structure

Concept	Keyword
Authentic Assessment	"authentic assessment" OR "performance assessment" OR "alternative assessment" OR "authentic evaluation" OR "genuine assessment"
4C Skills	"collaboration" OR "collaborative learning" OR "team work" OR "group work" OR creativity OR "creative thinking" OR innovation OR "innovative thinking"
Vocational Education	"vocatio* edu*" OR "vocational training" OR "technical education" OR "TVET" OR "career education" OR "occupational education" OR "futher edu*" OR "TAFE"

2.4. Selection and Analysis Process

The chosen articles comply with the PRISMA protocol by applying strict inclusion and exclusion criteria. English-language publications published between 2014 and 2024 that emphasize authentic evaluation in vocational education—with a focus on teamwork, creativity, or innovation—and that are open access are specifically listed as meeting the inclusion requirements. This ten-year period was chosen in response to (Okoli, 2015) suggestion that the results should remain relevant to current developments. Figure 1 shows

the PRISMA flow diagram illustrating the article selection process from the initial identification stage to the final synthesis.

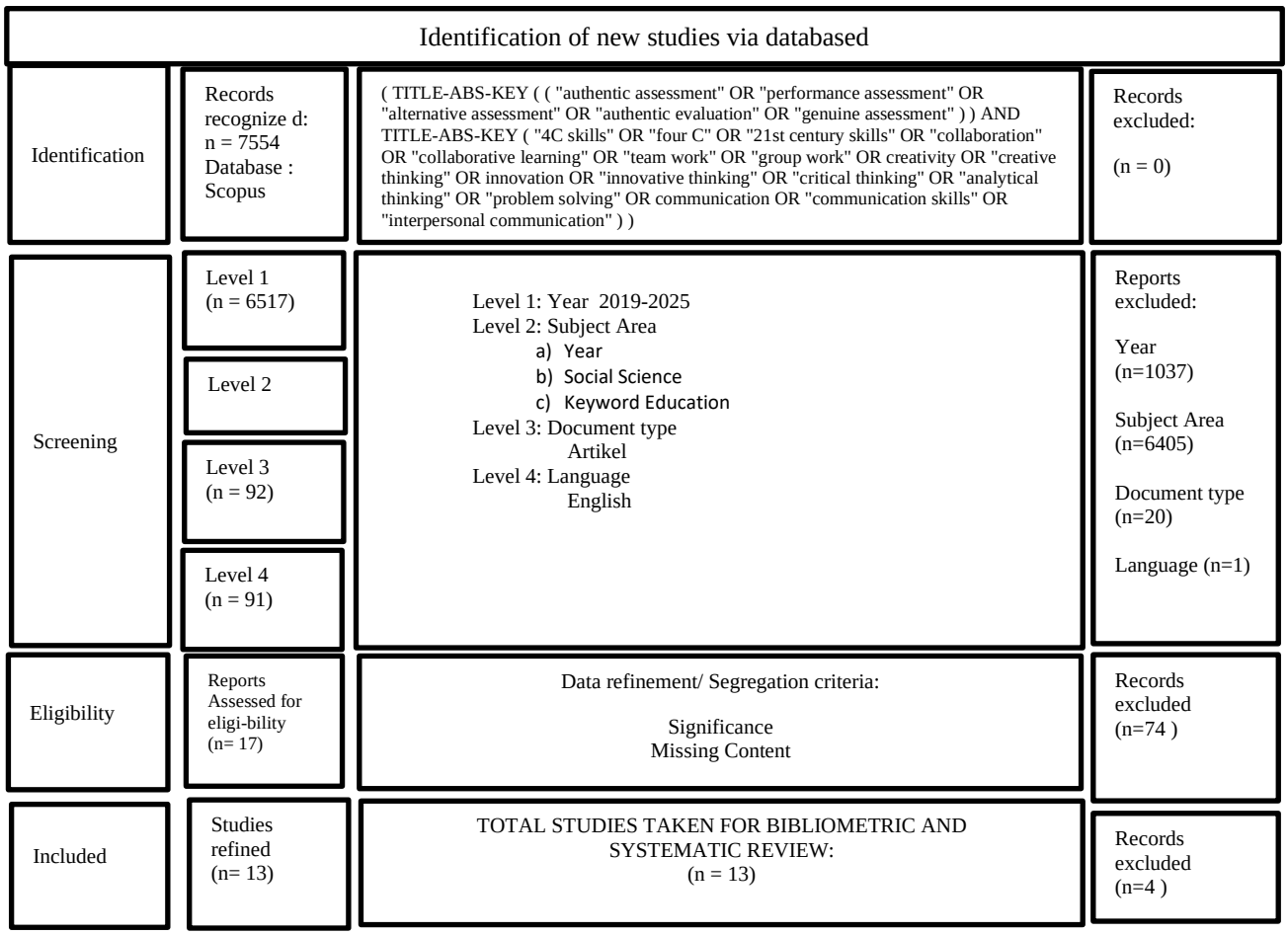

Figure 1. PRISMA diagram of the study selection process

Geographical analysis reveals the contributions from nine countries, with the highest proportion coming from the Netherlands (5 articles), Iran (4 articles), followed by Indonesia and the United States (each with 3 articles). Table 2 presents the analysis framework used.

Table 2. Data analysis framework

Analysis Aspects	Components Analyzed	Metode Analisis
Temporal-Geographic	Year of publication, country, institution	Frequency analysis and mapping
Methodological	Research design, data collection methods	Thematic categorization
Thematic	Research focus, main concepts	Content analysis
Synthesis	Key findings, implications	Qualitative meta-synthesis

2.5. Quality Assurance

The reliability of the analysis is ensured through an independent coding process conducted by two researchers, accompanied by discussions to reach consensus on cases that are not aligned. Inter-rater reliability is assessed through Cohen's kappa coefficient. As suggested by (Snyder, 2019) for systematic reviews in education, employing multiple data sources and analytical methods enhances the research's validity. Techniques such as member checks and peer debriefing serve as examples of verification methods.

Systematic reviews (3 articles), mixed methods (2 articles), qualitative studies (3 articles), experimental research (2 articles), case studies (2 articles), and development research (1 article) are all included in the methodological variety. From a variety of epistemological angles, this diversity offers a greater understanding of real 4C evaluation. Data analysis yields four key themes that are analyzed in detail in the results and discussion section: innovation in evaluation, collaboration and creativity, implementation challenges, and impact and sustainability. These topics emerge through a process of repeated coding and analysis, consistent with established qualitative research practice.

2.6. Study Analysis Method

This research employs a Systematic Literature Review (SLR) framework when addressing integration of authentic assessment of 4C skills with vocational education. Selection of the SLR framework is justified based on its ability to attain a comprehensive, clear, and reproducible synthesis of existing studies. Through a review of related studies emanating from a mix of sources, this research tries addressing best practices, challenges, and shortcomings of authentic assessment implementation within vocational education contexts. The study is aligned with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) criteria for ensuring consistency and rigors of review process throughout its entirety. Having shortlisted studies, a qualitative analysis thereof was conducted using thematic synthesis to identify patterns, trends, and observations recurring across studies. Thematic synthesis helps achieve identification of larger themes across studies, yet maintaining specified information of each study's results. Application of this method proved suitable given its ability to allow integration of both qualitative and quantitative information emanating from heterogeneous sources. The analysis proceeded under the following steps:

1. Information Extraction: Key information of each of the research studies was extracted, covering the purposes of studies, methodologies, sample sizes, assessement instruments used, noted challenges, and outcomes related to 4C skills development.
2. Coding and Categorization: The gathered data were afterward categorized according to the themes deduced, which are "technological integration," "collaborative assessment," "implementation challenges," and "impact on student competencies."
3. Thematic Analysis: The coded data were arranged in thematic categories in order to identify patterns and inconsistencies in the research results. Such a process enabled a thorough comprehension of current difficulties, shortcomings of current models, and model exemplars, which potentially inform future uses of authentic assessment.
4. Meta-Synthesis: A meta-synthesis was used to examine and combine results of studies employing a range of methodological designs (e.g., qualitative, quantitative, mixed-method) to draw more comprehensive inferences. This made it possible to reach a broader understanding of vocational education's genuine assessment practice effectiveness and challenges.

3. Results and Discussion

3.1. Data Extraction

Careful analysis of 13 relevant studies reveals significant development of 4C skills evaluation in vocational studies. The variety of subjects and careful elaboration of studies performed, accompanied by a steady number of publications ranging across the years 2014-2024, sum up to a picture of such development. Figure 2 shows a distribution of articles across the period of 2014-2024, revealing a growing tendency of studies performed in this ield and Figure 3 shows distribution of research methodology.

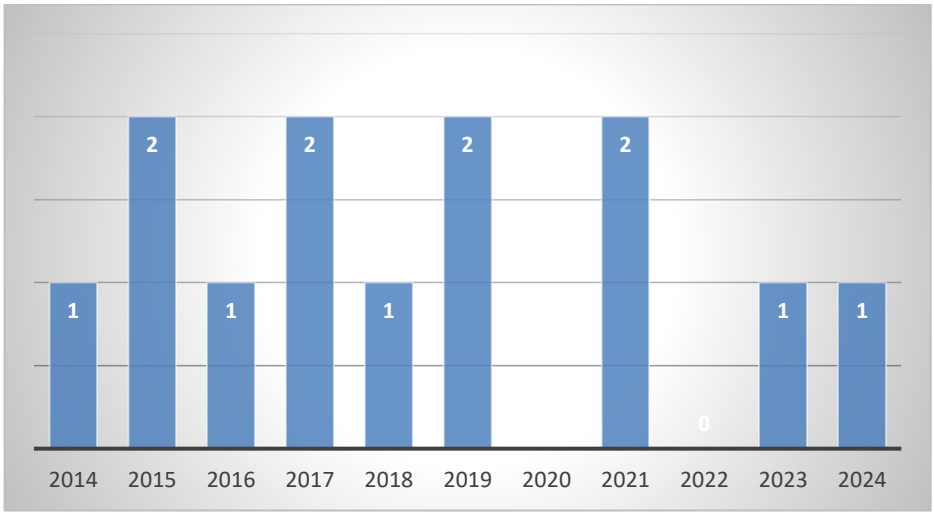

Figure 2. Temporal distribution of publication

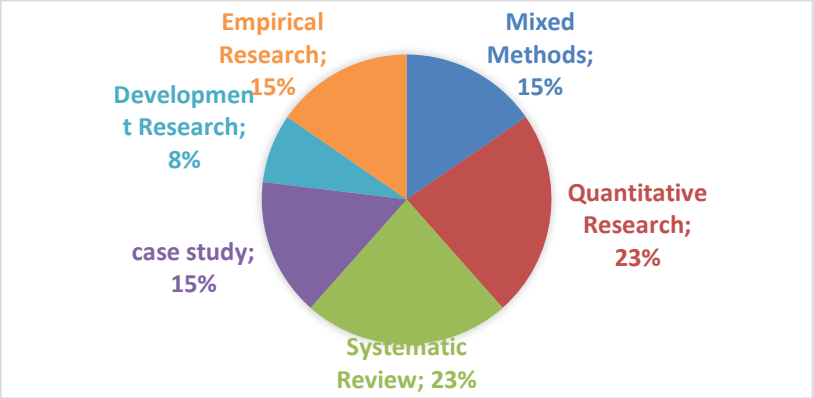

Figure 3. Country-Based Distribution of Research Methodologies

The geographical distribution of the study, which covers nine countries, offers an in-depth view of authentic assessment practices. The dominance of publications emanating from the Netherlands, which total five publications, highlights the sophisticated state of its vocational education system as a country. At the same time, the significant contributions of Iran (four publications) together with those of Indonesia and America (each of three publications) reflect growing global interest in this topic of study. This geographical diversity provides a deeper appreciation of applying genuine assessment in different cultural contexts and education systems.

To clarify the dynamics of the development of authentic assessment research in vocational education from year to year, data visualization is needed to more easily understand the distribution patterns of articles. Figure 4 displays a Bubble Timeline of published papers for three significant periods (2014–2017, 2018–2019, and 2020–2024), along with dominant research themes of each period. It is beneficial for both comprehension of published numbers and research focus shifts conducted during specified periods.

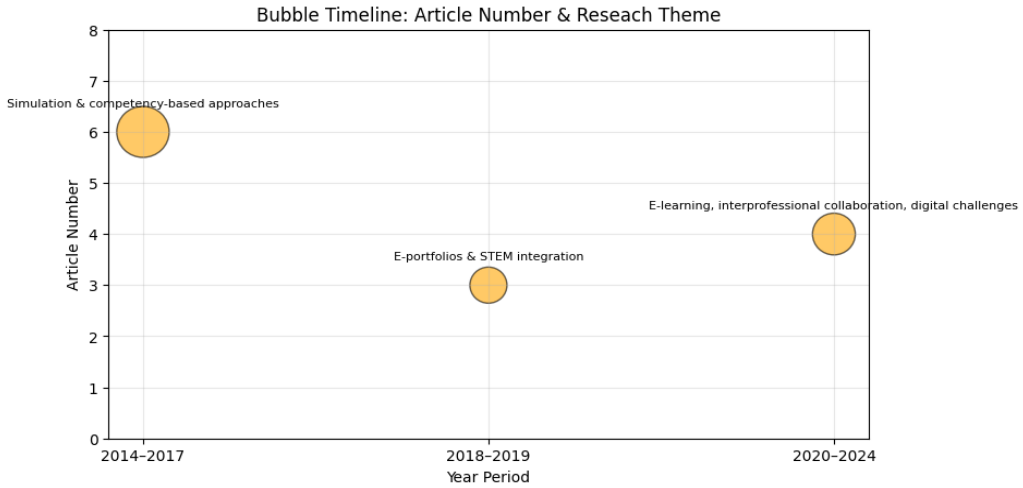

Figure 4. Bubble timeline: article number vs research

3.2. Article Categorization

Based on the 13 articles studied, the following discussion categories can be formed:

Table 3. Article grouping based on authentic assessment discussion

Group	Author and Year	Number of Citations	Discussion Information
Main Focus of Authentic Assessment	Jolly, Lochan dkk. (2021) Rao, Shreyas & Nayak, Ashalatha (2016) De Klerk, Sebastiaan dkk. (2014) Chen, Peng & Schmidtke, Carsten (2017)	0	Explicitly discusses authentic assessment, both in the form of evaluation techniques, multimedia-based assessment, and in the context of constructivism and contextual learning.
Self-Directed Learning & Feedback (indirect authentic assessment)	Beckers, Jorrick dkk. (2019)	22	E-portfolio, self-reflection, timely feedback, increased motivation and learning autonomy.
Vocational Education & Competence (implicit authentic)	Viet, Nguyen Quang (2017) Promboon, Sumonta dkk. (2018) Sudirman, A. (2019)	6	Vocational competencies, STEM application related to real activities, student-centered teaching innovation with a humanistic approach.
Interprofessional Collaboration & Competence	Rasouli, Davood dkk. (2024) Stephens, Geralyn E. (2015)	1	Team performance assessment, interprofessional collaboration in health, and the relationship between teacher background and collaborative practice.
E-learning & Digital Technology	Wagino, Wagino dkk. (2023)	6	E-learning environments, MOOCs, digital mind maps, and technology-based collaborative learning.
New Approaches to General Assessment & Evaluation	Taqwa AlHadidi & Hesham A. Rakha (2021) Moldovan, Liviu (2015)	0	A system-based accident analysis framework, as well as a new method for performance assessment with indicators.

Based on table 3, it can be seen that research on authentic assessment can be divided into several main focuses. Most studies discuss authenticity directly through uniqueness-based evaluation strategies, work environment simulations, the use of multimedia, and constructivist approaches. Others implicitly address it through the implementation of e-portfolios, feedback, vocational education, STEM learning, and interprofessional collaboration that emphasizes real-world skills. Furthermore, research in the context of e-learning and new assessment approaches also expands the meaning of authenticity in both the digital and methodological realms. This reveals that genuine assessment is recognized not merely as a process of assessment but also as a comprehensive approach concerning contextual learning, autonomy, co-operation, and preparation for life itself.

Also, categorizations may be done according to themes of technology incorporation, collaborative evaluation, implementation difficulties, and their effects on a learner's competencies.

Tabel 4. Grouping articles by theme

Theme	Article Author	Discussion Summary
Technological Integration	Wagino dkk. (2023), Beckers dkk. (2019), De Klerk dkk. (2014), Sudirman (2019)	Technology integration in learning and assessment: MOOCs, e-portfolios, multimedia (video, graphics, VR), and vocational technology innovation.
Collaborative Assessment	Wagino dkk. (2023), Rasouli dkk. (2024), Stephens (2015)	Collaboration-based assessment: team performance in healthcare, academic–industry collaboration, and digital collaborative learning.
Challenges in Implementation	Wagino dkk. (2023), Rasouli dkk. (2024), Sudirman (2019)	Barriers to implementation: limited digital infrastructure, lack of credible instruments for collaboration, and the risk of losing the humanistic aspect.
Impact on Student Competencies	Jolly dkk. (2021), Viet (2017), Promboon dkk. (2018), Beckers dkk. (2019), Rao & Nayak (2016), Chen & Schmidtke (2017)	Impact on competencies: strengthening of real skills, motivation, self-reflection, integration of professional attitudes, situational cognition, and application of STEM in real life.

Table 4 shows that studies on authentic assessment are connected to four main themes. In the case of integration of technologies, studies conducted by scholars suggest the adoption of MOOCs, e-portfolios, multimedia texts, and vocational technology innovations as ways of embracing more authentic modes of assessment. The shared assessment theme highlights teamwork-based assessments, predominantly in online worlds and interprofessional practice in health and industrial scenarios, respectively. Likewise, the theme of implementation challenges highlights real-world challenges, including a poor information infrastructure, absence of reliable assessment tools, and potential weakening of the humanistic orientation of teaching and learning. The theme of consequences for student competence identifies how authentic approaches have a beneficial influence on intrinsic motivation, reflectiveness, absorption of professional dispositions, integration of STEM into real-world activities, and acquisition of related work-centred skills. These findings indicate that authentic assessment is not only influenced by technological support and collaboration but also faces implementation challenges that directly impact the quality of student competencies.

Thematic Analysis

The coded data were grouped into thematic categories to identify patterns and variations in the research findings. Two overarching dimensions emerged from the analysis.

First, studies that explicitly addressed authentic assessment highlighted strategies to make evaluation more meaningful and contextual, such as using unique and unpredictable test items, employing multimedia and simulations, and embedding assessment within constructivist and real-world learning contexts. Other studies contributed indirectly by linking authentic assessment to related areas such as vocational education, self-directed learning, feedback, collaboration, and digital learning environments. This indicates that authentic assessment is conceptualized both as a direct evaluative approach and as an implicit component embedded in broader pedagogical innovations.

Second, when coded under thematic categories of technological integration, collaborative assessment, challenges in implementation, and impact on student competencies**,** further variations were observed. Research on technological integration emphasized the use of MOOCs, e-portfolios, and multimedia to support authentic learning experiences. Collaborative assessment studies explored teamwork and interprofessional evaluation as essential for authentic performance measurement. Challenges in implementation were evident in the form of infrastructural limitations, lack of credible instruments, and risks of dehumanization in overly technology-driven environments. Finally, the impact on student competencies emerged as a consistent outcome, with studies reporting improvements in motivation, reflection, professional attitudes, contextual STEM application, and readiness for real-world tasks.

In this study, thematic analysis shows that research on authentic assessment can be grouped into several broad, complementary themes. In the technological integration dimension, the use of digital media such as MOOCs, digital mind maps, e-portfolios, and multimedia simulations has been shown to enrich authentic assessment practices in both vocational and independent learning contexts ((Wagino et al., 2023); (Beckers & Halpern, 2019); (de Klerk et al., 2018); (Liu et al., 2019)). The collaborative assessment theme emphasizes the importance of teamwork-based evaluation, both through online collaborative learning and interprofessional collaboration in the healthcare sector, which reflects the competency demands of the real world of work ((Rasouli et al., 2024); (Stephens et al., 2015); (Wagino et al., 2023)). However, implementation challenges also arise, such as limited digital infrastructure, the lack of credible instruments, and the risk of diminishing humanistic aspects when technology becomes too dominant ((Rasouli et al., 2024); (Wagino et al., 2023); (Liu et al., 2019)). Regarding the impact on student competencies, research shows that authentic assessment can improve motivation, reflective skills, integration of

professional attitudes, and the ability to apply STEM in real-life contexts ((Jolly et al., 2021); (Viet, 2017); (Promboon et al., 2018b); (Beckers & Halpern, 2019); (Rao & Nayak, 2017); (Chen & Schmidtke, 2017)). Thus, authentic assessment is understood not only as an evaluation method but also as a pedagogical strategy that emphasizes technology integration, collaboration, and strengthening student competencies to face the challenges of 21st-century learning. Overall, these thematic categories reveal that authentic assessment is not only a methodological approach but also a multidimensional concept shaped by technology, collaboration, contextual challenges, and its ultimate influence on students' competencies.

3.3. Meta-Synthesis

A meta-synthesis was conducted to compare and integrate findings from studies with different methodological approaches, including qualitative, quantitative, and mixed-methods research. The synthesis revealed that qualitative studies primarily emphasized the exploration of authentic assessment within learning contexts, such as the use of multimedia simulations, e-portfolios, MOOCs, and collaborative learning environments, highlighting rich descriptions of implementation processes and learner experiences. In contrast, quantitative studies tended to measure the impact of authentic and innovative assessment methods on specific outcomes, such as student motivation, reflective capacity, competency development, and professional readiness, thereby providing statistical evidence of effectiveness. Meanwhile, mixed-methods studies bridged these perspectives by examining both the practical challenges—such as infrastructural barriers, insufficient assessment instruments, and risks of dehumanization in digital settings—and the measurable benefits of authentic assessment in enhancing collaboration and contextual learning.

By integrating these diverse findings, the meta-synthesis concludes that authentic assessment is best understood as a multidimensional construct: it requires technological integration to enrich assessment modalities, collaborative approaches to reflect real-world teamwork, careful consideration of implementation challenges, and a strong focus on its ultimate impact on student competencies. This comprehensive perspective underscores that authentic assessment is not only an evaluative tool but also a pedagogical strategy that links teaching, learning, and professional practice across educational contexts.

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3.4. Guide for Implementing Authentic Assessment of 4C Skills

Based on the 13 articles studied, several ideas can be made in implementing Authentic Assessment to evaluate 4C skills in Vocational Education:

1. Critical Thinking

   Developing scenario-based authentic assessments based on multimedia and AR/VR ((de Klerk et al., 2018); (Promboon et al., 2018a)) that require students to analyse complex workplace issues, make decisions, and provide justification. This can enhance critical thinking skills in a contextual manner.
2. Creativity

   Implementing digital portfolios allows students the freedom to showcase innovative projects (Beckers & Halpern, 2019), coupled with blockchain integration to maintain the authenticity of their work. This way, assessments measure not only the final results but also the students' creative process in designing vocational solutions.
3. Collaboration

   Designing a hybrid collaborative assessment with authentic industry-based projects, combining online assessment (e-learning) and hands-on practice ((Wagino et al., 2023); (Rasouli et al., 2024)). The instrument can assess individual contributions, team

interactions, and collective outcomes, in line with the demands of the vocational workplace.

4. Communication

   Developing a performance-based assessment in which students present their vocational solutions or products to a panel of assessors (e.g., lecturers, industry practitioners, or peers). This approach expands the emphasis on professional communication previously discussed in the context of vocational teaching. ((Stephens et al., 2015); (Chen & Schmidtke, 2017)).

Thus, the transformation of authentic assessment for 4C in vocational education not only measures the technical aspects of skills, but also assesses students' readiness to face the complex challenges of modern industry.

3.5. Collaboration with Industry

To strengthen the implementation of authentic assessment in vocational education, collaboration with industry can be a key aspect to ensure that assessments truly reflect the needs of the workplace. Here are some innovative ideas for collaboration with industry:

1. Co-Design Assessment Tasks

   Industry is involved from the outset to design authentic assignments based on real-world projects, such as solving technical problems or designing products according to company standards. This strengthens the relevance between assessment results and job competency needs.

2. Industry-Based Mentoring and Feedback

   Industry practitioners act as external assessors or mentors who provide direct feedback on student performance (Rasouli et al., 2024). This mechanism helps assess soft skills such as professional communication, collaboration, and work ethic.

3. Simulation of Workplace Environments

   With industry support, vocational institutions can develop authentic assessments based on work simulations (e.g. using AR/VR or case-based assessments) that reflect real situations in factories, workshops, or offices. ((de Klerk et al., 2018); (Promboon et al., 2018a)).

4. Joint Evaluation through Digital Portfolios

   Industry is given access to students' digital portfolios (Beckers & Halpern, 2019), allowing companies to see authentic evidence of students' skills, innovations, and projects. Blockchain technology can be used to maintain authenticity and accountability.

5. Assessment Aligned with Industry 4.0/5.0 Competencies

Together with industry, vocational institutions can design authentic assessments that explicitly measure 21st-century competencies and future skills, such as critical thinking, creativity, human-machine collaboration, and digital literacy. ((Liu et al., 2019); (Wagino et al., 2023)).

6. Capstone Projects with Industry Partners

   Providing a final project (capstone) designed and evaluated in collaboration with a partner company. This project can involve solving a real-world industrial problem, so students are assessed based on their problem-solving and ability to generate innovative solutions.

With this scheme, authentic assessment not only functions as an academic evaluation tool, but also becomes a bridge between vocational education and the industrial world, while strengthening the employability of graduates.

3.6. Practical Implications for Educators and Policymakers

Given the importance of authentic assessment as a strategic instrument for bridging the gap between classroom learning and real-world industry needs, implementation requires strong support from educators and policymakers, both in terms of curriculum design, teacher capacity, and digital infrastructure. Therefore, it is crucial to formulate practical implications that can provide concrete guidance for educators and policymakers in transforming assessment in vocational education to make it more relevant, credible, and oriented towards graduate employability. Here are some ideas needed for educators and policymakers::

1. Curriculum Alignment with Industry Needs
   - *Educators*: Aligning assessments with vocational skills required in industry, for example through real-world case-based projects.
   - *Policymakers*: Establish regulations that encourage active collaboration between vocational schools and industry in designing assessments.
2. Capacity Building for Teachers
   - *Educators*: Developing teacher competencies in designing authentic *assessment* technology-based (e-portfolios, AR/VR, digital feedback).
   - *Policymakers*: Providing ongoing training programs and specialized certification for vocational teachers to be ready to implement innovative assessments.

3. Integration of Technology
   - *Educators*: Leveraging digital platforms (e.g., MOOCs, e-portfolios, blockchain-based credentialing) to support transparent and flexible assessment.
   - *Policymakers*: Allocate funds and digital infrastructure so that technology-based assessments can be implemented evenly, especially in areas with limited access.
4. Promoting 4C Competencies (Critical Thinking, Creativity, Collaboration, Communication)
   - *Educators*: Design authentic assignments that measure the 4Cs through collaborative projects, professional presentations, and simulated work environments.
   - *Policymakers*: Incorporating 4C measurement as a national indicator in vocational education, not just technical skills.
5. Assessment for Employability
   - *Educators*: Linking assessment results to industry-accessible digital badges or portfolios as evidence of students' real competencies.
   - *Policymakers*: Create policies that recognize authentic assessment results as part of national competency certification.
6. Ensuring Equity and Accessibility
   - *Educators*: Developing inclusive assessment designs, taking into account students with diverse backgrounds and abilities.
   - *Policymakers*: Develop policies to reduce the digital divide and ensure all students have equal access to authentic, technology-based assessments.

In this way, educators gain practical direction for classroom and teaching innovation, while policymakers gain strategic guidance in formulating regulations, funding, and assessment standards that are relevant to the needs of modern industry.

4. CONCLUSION

This study confirms that authentic assessment is a strategic approach in vocational education for evaluating 21st-century competencies, particularly the 4Cs (critical thinking, creativity, communication, and collaboration). The findings of the Systematic Literature Review across 13 articles demonstrate that technological integration, collaborative assessment, and context-based projects can effectively enhance students' motivation, reflection, and professional readiness. Nevertheless, significant challenges remain, including limited digital infrastructure, the lack of credible instruments, and the potential risk of diminishing humanistic values due to technology-driven practices. Therefore, the implementation of authentic assessment should be directed toward the development of

adaptive, inclusive, and future-oriented models through close collaboration with industry and the support of appropriate policies. In this way, authentic assessment is positioned not merely as a tool for evaluation, but as a transformative mechanism to align vocational education with global demands and the modern workforce.

5. ACKNOWLEDGE

The researcher expresses sincere gratitude towards the research guide, esteemed colleagues, and affiliated institutions for their insightful suggestions and invaluable contributions. Their guidance and support have been instrumental in facilitating the data collection process, enabling rigorous analysis, and shaping the comprehensive review paper.

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