Enhancing Vocational Education and Sustainable Graduate Employment through Intelligent Dashboards in South African Higher Education: A Systematic Literature Review

Удосконалення професійної освіти та забезпечення сталого працевлаштування випускників за допомогою інтелектуальних інформаційно-аналітичних панелей у закладах вищої освіти Південно-Африканської Республіки: систематичний огляд літератури

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Purpose. This study aims to examine the potential of intelligent data-visualization dashboards to strengthen vocational education and support sustainable graduate employment in South African higher education by integrating human capital and signaling theories.

Design/methodology/approach. The study employs a systematic literature review guided by PRISMA principles and a narrative thematic synthesis of research published between 2011 and 2026. The review examines graduate skills mismatch, vocational education, dashboard technologies, and institutional decision-making, with particular attention to the South African context.

Findings. The reviewed literature identifies persistent discrepancies between graduates' acquired competencies and labor market requirements, as well as the growing potential of data visualization technologies to support evidence-based institutional decisions. However, direct empirical evidence demonstrating that dashboard-enabled visibility of skills improves sustainable employment outcomes remains limited.

Theoretical implications. Integrating human capital theory and signaling theory provides a conceptual explanation of how verified vocational competencies, communicated through intelligent dashboards, may reduce information asymmetry between graduates and employers.

Originality/value. The study proposes the Skills-Visibility-to-Sustainable-Employment Pathway, a four-stage conceptual model connecting vocational skills acquisition, dashboard-enabled skills visibility, reduced signaling friction, and sustainable employment outcomes.

Мета дослідження. Дослідити потенціал інтелектуальних інформаційних панелей для вдосконалення професійної освіти та сприяння сталій зайнятості випускників закладів вищої освіти Південно-Африканської Республіки.

Методологія дослідження. Застосовано систематичний огляд наукової літератури за 2011–2026 роки з урахуванням принципів PRISMA, наративного тематичного синтезу, теорії людського капіталу та теорії сигналів. Проаналізовано проблеми невідповідності компетентностей випускників потребам ринку праці, можливості інформаційних панелей та організаційні умови їх упровадження.

Результати дослідження. Встановлено, що невідповідність набутих компетентностей вимогам роботодавців залишається суттєвою проблемою працевлаштування випускників. Визначено потенціал інтелектуальних інформаційних панелей для систематизації, візуалізації та представлення підтверджених професійних компетентностей. Водночас безпосередній вплив таких технологій на сталість зайнятості потребує емпіричного підтвердження.

Теоретичні наслідки. Інтеграція теорії людського капіталу та теорії сигналів дозволяє пояснити потенційний механізм зменшення інформаційної асиметрії між випускниками та роботодавцями завдяки підвищенню доступності достовірної інформації про їхні професійні компетентності.

Наукова новизна. Запропоновано чотириетапну концептуальну модель SVSE, яка поєднує набуття професійних компетентностей, їхню візуалізацію, зменшення інформаційних бар'єрів і досягнення сталої зайнятості.

Перспективи подальших досліджень. Передбачено емпіричну перевірку моделі SVSE та оцінювання її результативності в закладах освіти з різним рівнем ресурсів. Особливу увагу доцільно приділити достовірності показників компетентностей, захисту персональних даних,

Further research. Future studies should empirically validate the proposed model and assess its effectiveness across different institutional contexts.

Article Type: Review Article.

Keywords: vocational education; intelligent dashboards; sustainable graduate employment; human capital theory; signaling theory; skills mismatch; South Africa.

доступності технологій та оцінюванню фактичних результатів працевлаштування випускників.

Тип статті: оглядова наукова стаття.

Ключові слова: професійна освіта; інтелектуальні інформаційні панелі; стабільна зайнятість випускників; теорія людського капіталу; теорія сигналів; невідповідність компетентностей; Південно-Африканська Республіка.

Introduction

The higher education system in South Africa faces a persistent challenge: despite improvements in educational access and the expansion of post-school education, graduate unemployment and skills mismatches remain significant concerns. Existing research indicates that these challenges stem from structural discrepancies between the competencies developed by educational institutions and the evolving requirements of the labor market. Such discrepancies may reduce the economic returns on educational investment and limit the effective utilization of graduates' human capital (Nyalungu, 2011; Curran et al., 2026; Cabral et al., 2025; Maimela & Mbonde, 2025; Moloto et al., 2025).

Within this context, vocational education, delivered through Technical and Vocational Education and Training (TVET) colleges and vocationally oriented higher education programs, plays an important role in developing practical, industry-relevant competencies. Nevertheless, studies conducted in South Africa indicate that vocational education continues to face challenges related to skills mismatches, graduate unemployment, and discrepancies between acquired qualifications and workplace requirements. These challenges highlight the need not only to improve the quality and relevance of vocational training but also to strengthen mechanisms through which graduates' competencies are communicated to potential employers.

Intelligent data visualization dashboards have emerged as valuable technological tools for supporting evidence-based decision-making in higher education. In South Africa, the application of business intelligence technologies to institutional strategic planning was documented as early as 2011, including their implementation at the University of the Witwatersrand (Nyalungu, 2011). More recent studies demonstrate the growing relevance of dashboards and learning analytics for institutional management, performance monitoring, and educational decision-making (Cabral et al., 2025; Curran et al., 2026). However, the effectiveness of these technologies depends not only on their technical capabilities but also on institutional governance, organizational culture, data quality, and stakeholders' capacity to interpret and apply analytical information.

Despite growing research on graduate skills mismatches and the increasing adoption of data visualization technologies in higher education, the relationship between these areas remains underexplored. In particular, limited attention has been devoted to examining how intelligent dashboards could make verified vocational competencies more accessible and understandable to employers, thereby potentially reducing information asymmetry in graduate recruitment. This issue is especially relevant in labor markets where formal qualifications do not always provide sufficiently detailed or reliable information about graduates' actual competencies.

Addressing this research gap requires an interdisciplinary perspective that integrates labor economics, information science, and higher education management. Human capital theory provides a foundation for understanding how vocational education contributes to the development of productive competencies, while signaling theory explains how information about these competencies influences employers' recruitment decisions. Integrating these theoretical perspectives may help explain the potential role of intelligent dashboards in enhancing the visibility of graduates' skills and supporting more effective alignment between vocational education and labor market requirements.

Accordingly, this study addresses three research questions:

1. What does the existing literature reveal about the main factors contributing to vocational

graduate skills mismatches and challenges associated with sustainable employment in South Africa?

2. How can intelligent data visualization dashboards support institutional decision-making and improve the accessibility and interpretation of information about graduates' competencies?
3. How can existing theoretical and empirical evidence be integrated into a conceptual framework explaining the potential contribution of dashboard-enabled skills visibility to sustainable graduate employment?

The purpose of this study is to systematically examine the relevant literature and develop a conceptual framework explaining how intelligent dashboards may strengthen the relationships among vocational education, graduates' competencies, and sustainable employment outcomes in South African higher education.

The principal contribution of the study is the development of the Skills-Visibility-to-Sustainable-Employment (SVSE) Pathway, which integrates vocational skills acquisition, dashboard-enabled skills visibility, reduced signaling friction, and sustainable employment into a unified conceptual model. The proposed framework is intended to provide a theoretical foundation for future empirical investigations rather than establish a direct causal relationship between dashboard implementation and employment outcomes.

The remainder of the paper is organized as follows. Section 2 presents the theoretical foundations of the study, focusing on human capital theory and signaling theory. Section 3 reviews the relevant literature, while Section 4 summarises the characteristics of the selected studies. Section 5 describes the systematic literature review methodology. Section 6 discusses the findings and introduces the proposed SVSE Pathway. Finally, Sections 7 and 8 present the conclusions, limitations, and directions for future research.

Literature Review

The literature review examines existing theoretical and empirical evidence on the relationship among vocational education, graduate skills mismatches, intelligent data visualization dashboards, and sustainable employment in South Africa. The analysis is organized into five interrelated thematic areas: graduate skills mismatches and employment challenges; the role of vocational education; dashboard technologies as decision-support infrastructure; institutional adoption constraints; and the identification of the research gap.

This thematic approach provides a foundation for understanding the interaction between vocational skills development, labor-market requirements, and information technologies. It also establishes the empirical and conceptual basis for the theoretical framework presented in the subsequent section.

1. Graduate Skills Mismatch and Unsustainable Employment in South Africa

Graduate skills mismatch represents a persistent challenge within South Africa's higher education system and labor market. Existing research identifies structural discrepancies between the competencies developed through educational programs and those required by employers as an important factor contributing to graduate unemployment and underemployment.

Moloto et al. (2025), in a systematic literature review synthesizing 43 peer-reviewed studies conducted over approximately two decades, identify weaknesses in the alignment between educational planning and labor-market requirements as recurring contributors to graduate unemployment. Their findings suggest that insufficient coordination between higher education institutions, policymakers, and employers may perpetuate discrepancies between educational outcomes and employment opportunities.

Empirical research provides additional evidence of these challenges at the individual level. Mncayi and Dunga (2016) examine the relationship between graduates' fields of study, career choices, and unemployment duration, highlighting the importance of educational and occupational

alignment for labor-market integration. Similarly, Mncayi and Meyer (2022) investigate determinants of perceived underemployment among young South African university graduates, demonstrating that underemployment constitutes a distinct dimension of labour-market disadvantage.

Taken together, these studies indicate that sustainable graduate employment should not be assessed solely by obtaining a job. It should also consider the correspondence between acquired competencies and occupational requirements, the effective utilization of graduates' skills, and the continuity and quality of employment.

However, skills mismatches and graduate unemployment are multidimensional phenomena influenced by educational quality, labor-market demand, institutional coordination, and broader socioeconomic conditions. Consequently, improving the visibility of graduates' competencies may address certain informational barriers but cannot, on its own, resolve structural employment challenges.

2. Vocational Education's Position within the Mismatch

Vocational education plays a significant role in efforts to improve graduate employability and strengthen the alignment between educational outcomes and labor market requirements. TVET institutions are intended to develop practical, occupation-specific competencies that support graduates' transition into employment.

Nevertheless, vocational education systems continue to experience challenges that may limit their effectiveness. Mayombe (2021), in a comprehensive examination of vocational education and training across Sub-Saharan Africa, identifies constraints associated with institutional resources, industry partnerships, and quality assurance. These factors may weaken the alignment between training programs and actual workplace requirements.

Such findings suggest that the effectiveness of vocational education depends not only on the provision of technical training but also on the relevance, quality, and recognition of the competencies acquired.

From this perspective, vocational qualifications may not always provide employers with sufficiently detailed information about graduates' practical capabilities. However, the existence of a skills mismatch does not necessarily indicate a failure of competency signaling. It may also reflect deficiencies in training provision or insufficient demand for particular occupational skills.

This distinction is important because interventions designed to improve the communication of competency information should complement, rather than replace, measures aimed at improving the quality of vocational education and labor-market alignment.

Accordingly, the reviewed literature supports further examination of mechanisms to strengthen the transparency and credibility of information on vocational competencies, while recognizing the broader structural determinants of graduate employment.

3. Dashboard Technology as Institutional Decision Infrastructure

Intelligent data visualization dashboards have become increasingly relevant as technological instruments for supporting institutional management, performance monitoring, and evidence-based decision-making in higher education.

In South Africa, the application of business intelligence technologies to university strategic planning was documented by Nyalungu (2011), who examined the implementation of a business intelligence framework at the University of the Witwatersrand. This study illustrates an early institutional application of data integration and analytical tools to support strategic decision-making.

More recent international research has expanded the understanding of dashboard technologies and their potential applications within educational systems.

Curran et al. (2026), through a systematic review of systems-level data dashboards, examine their role in educational leadership and policy decision-making. Their findings highlight the capacity of dashboards to improve the accessibility and interpretation of information while also

demonstrating that the selection and presentation of indicators may influence how decision-makers interpret institutional performance.

Similarly, Cabral et al. (2025) identify institutional decision-making as an important application area for artificial intelligence-powered learning analytics dashboards. Their review demonstrates the growing integration of analytical technologies into educational management and the potential of these systems to support data-informed interventions.

Evidence from South Africa further illustrates the availability of relevant analytical capabilities. Ajoodha et al. (2020) demonstrate the application of machine learning techniques for forecasting student attrition using institutional data from a South African university. Although this research does not directly examine vocational graduate employment, it provides an example of predictive analytical methods that could potentially contribute to more advanced institutional information systems.

Collectively, these studies establish that dashboard technologies can support the collection, integration, analysis, and visualization of educational data. However, most documented applications focus on institutional performance, student engagement, retention, and educational decision-making rather than the external communication of verified vocational competencies to employers.

This distinction reveals an opportunity to extend the application of intelligent dashboards beyond internal institutional management to support labor-market information exchange and graduate employment matching.

4. Institutional Adoption Constraints and Stratification

Despite the growing availability of intelligent analytical technologies, their effective implementation in higher education depends on institutional, organizational, and socioeconomic conditions.

Chomunorwa (2026), in a South African institutional case study, identifies organizational barriers to data-driven decision-making, including hierarchical governance structures and limitations in feedback mechanisms. These findings suggest that access to analytical information does not automatically lead to its effective application in institutional management processes.

Broader research on digital technology adoption in South African higher education also highlights inequalities between institutions. Maimela and Mbonde (2025) examine artificial intelligence adoption and curriculum transformation, highlighting differences in institutional capabilities and the challenges of technological integration.

These findings indicate that the benefits of advanced analytical systems may be distributed unevenly across higher education institutions. Historically advantaged institutions may possess stronger financial, technological, and organizational capacities to implement such systems, whereas resource-constrained institutions may face additional barriers.

Although the reviewed studies do not directly investigate the visibility of dashboard-enabled vocational skills, they identify contextual factors to consider when developing and implementing such technologies.

In particular, initiatives intended to improve graduate employment through intelligent dashboards should address data accessibility, institutional readiness, technological infrastructure, information governance, and stakeholders' capacity to interpret and use analytical outputs.

Failure to consider these conditions could reinforce existing inequalities in access to educational technologies and labor-market opportunities.

5. Learning Analytics Dashboards and Student Engagement

The development of learning analytics dashboards has significantly expanded opportunities to monitor educational processes, interpret student performance data, and support evidence-informed decision-making in higher education. Existing research demonstrates that the functionality of these technologies increasingly extends beyond the visual presentation of educational indicators towards facilitating learning, reflection, and institutional interventions.

Schwendimann et al. (2017), in a systematic literature review of learning dashboard research, examine the purposes, data sources, visualization approaches, intended users, and reported educational effects of dashboard technologies. Their findings provide an important foundation for understanding the design and application of analytical dashboards in educational environments.

Ifenthaler and Yau (2020) further demonstrate the potential of learning analytics to support student success by identifying educational needs, monitoring learning progress, and implementing data-informed interventions. Their findings highlight the importance of transforming educational data into actionable information that can support academic decision-making.

Paulsen and Lindsay (2024) identify a shift in dashboard development from systems primarily designed to display analytical information towards technologies intended to actively support student learning, reflection, and engagement. This development suggests that dashboard effectiveness should be assessed not only through technical functionality but also through its contribution to educational processes and user decision-making.

Similarly, Bergdahl et al. (2024) examine the relationship between learning analytics and student engagement, emphasizing the importance of meaningful interpretation, contextual understanding, and student involvement in analytics-supported educational activities.

Kaliisa et al. (2023) contribute to this discussion by proposing a practical checklist for planning, designing, implementing, and evaluating learning analytics dashboards. Their work highlights the need for systematic, user-centered approaches that consider educational objectives, stakeholder requirements, and evaluation procedures.

The broader digital transformation of higher education provides an additional context for these developments. Rienties et al. (2023) examine Education 4.0 and its implications for digital technologies, data-driven learning, and the development of future-oriented competencies.

Taken together, these studies indicate that intelligent dashboards may contribute to educational improvement when their design is aligned with clearly defined objectives, reliable data, and stakeholder needs.

For vocational education, these findings provide a conceptual basis for extending dashboard applications beyond monitoring student performance towards representing acquired competencies and supporting transitions from education to employment. However, the effectiveness of such applications in improving graduate employment outcomes remains to be empirically established.

6. Ethical Governance, Data Privacy, and Institutional Context

The implementation of intelligent data visualization dashboards in higher education raises important questions concerning data governance, privacy, transparency, institutional responsibility, and the ethical interpretation of analytical information.

Prinsloo (2019) critically examines educational analytics as an institutional practice shaped by relationships between data, power, agency, and decision-making. This perspective highlights that analytical technologies are not neutral instruments, as their design and application may influence how institutions interpret educational performance and make decisions affecting students.

Prinsloo and Slade (2019) trace the development of ethical approaches to student data, emphasizing privacy, transparency, accountability, and responsible data governance. Their work demonstrates the importance of establishing clear ethical principles when collecting, analyzing, and applying educational information.

Prinsloo (2022) extends this discussion to the African context, examining the opportunities and challenges associated with data privacy in learning analytics. The study highlights the need for context-sensitive approaches that account for institutional conditions, regulatory environments, and the rights of individuals whose data are processed.

Prinsloo et al. (2024) conceptualize learning analytics within a broader data ecology involving people, technologies, institutions, policies, and data practices. This perspective suggests that the

effectiveness of analytical systems depends on the interaction between technological infrastructure and the institutional environments in which data are generated, interpreted, and used.

These contributions are particularly relevant to the proposed application of intelligent dashboards for vocational skills visibility. Providing employers with access to competency-related information requires appropriate safeguards concerning data accuracy, consent, access rights, transparency, and responsible interpretation.

Furthermore, the external communication of educational data introduces additional governance considerations beyond those associated with dashboards designed exclusively for internal institutional use.

Consequently, the development of dashboard-enabled skills visibility mechanisms should incorporate ethical and organizational requirements from the initial design stage rather than treating them as secondary implementation concerns.

Within the proposed SVSE Pathway, these considerations are essential to establishing credible and responsible mechanisms for communicating vocational competencies to prospective employers.

7. Inclusive Entrepreneurship Education, Work-Integrated Learning, and Graduate Employability

The relationship between vocational education and sustainable graduate employment extends beyond the acquisition of technical competencies. Existing research also highlights the importance of entrepreneurial capabilities, inclusive educational practices, workplace experience, and the development of competencies relevant to changing labor-market conditions.

Gumbs et al. (2026), in a literature review on entrepreneurial competencies and inclusive education, examine the importance of accessible educational approaches in developing entrepreneurial capabilities. Their work highlights the relevance of educational inclusion to competency development and participation in entrepreneurship-oriented learning.

Owusu-Acheampong et al. (2025) investigate factors influencing the effectiveness of entrepreneurship education in higher education institutions across Sub-Saharan Africa. Their scoping review identifies institutional, curricular, resource-related, and pedagogical factors that may affect educational outcomes.

Within the South African context, Sivasanker and Beharry-Ramraj (2026) examine the importance of bridging theoretical instruction and practical experience in entrepreneurship education. Their findings emphasize the role of experiential learning in strengthening entrepreneurial competencies.

The transformation of vocational education in response to technological change is also addressed by Kana and Letaba (2024), who examine curriculum transformation in South African TVET colleges in the context of the Fourth Industrial Revolution. Their research highlights the importance of developing contemporary competencies that respond to changing occupational and technological requirements.

Paterson et al. (2021) highlight work-based values as an important component of youth employability. Their findings suggest that successful labor-market integration depends not only on technical knowledge but also on workplace-related expectations and professional behaviors.

Nduna (2026) examines barriers to effective work-integrated learning in South African colleges, identifying challenges that may affect students' transition from educational institutions to employment. These findings reinforce the importance of practical learning opportunities and cooperation between educational institutions and employers.

Funda and Mbangeleli (2024) explore the potential of artificial intelligence to address academic challenges in South African higher education. Their research contributes to the broader discussion of how emerging technologies may support educational processes and institutional development.

Collectively, these studies demonstrate that graduate employability is influenced by a combination of technical competencies, entrepreneurial capabilities, workplace experience, educational inclusion, and institutional support.

For the present study, this evidence suggests that intelligent dashboards should not be limited to displaying formal qualifications or academic performance indicators. Their potential application may also involve presenting verified information about practical training, work-integrated learning, entrepreneurial competencies, and other relevant educational achievements.

Nevertheless, the inclusion of additional competency indicators does not necessarily establish their predictive validity for employment outcomes. Their usefulness would depend on the quality of assessment procedures, the relevance of selected indicators, and employers' willingness to incorporate such information into recruitment decisions.

These considerations provide an additional basis for developing the proposed SVSE Pathway while emphasizing the need for empirical validation and context-sensitive implementation.

8. Summary and Research Gap

The reviewed literature provides a multidimensional understanding of the relationship between vocational education, graduate employability, intelligent data visualization technologies, and institutional conditions in South African higher education.

First, research on graduate unemployment and skills mismatches identifies persistent discrepancies between educational outcomes and labor-market requirements. These challenges are associated with structural, institutional, and socioeconomic factors that influence graduates' transition into employment.

Second, studies of vocational and entrepreneurship education emphasize the importance of relevant technical competencies, practical training, entrepreneurial capabilities, inclusive educational approaches, and work-integrated learning. These factors contribute to graduate employability but do not independently guarantee sustainable employment outcomes.

Third, research on learning analytics and intelligent dashboards demonstrates their potential to support educational monitoring, student engagement, institutional management, and evidence-informed decision-making. However, most documented applications focus on internal educational processes rather than on communicating verified vocational competencies to prospective employers.

Fourth, the literature on educational data governance highlights the importance of privacy, transparency, accountability, stakeholder participation, and institutional context. These considerations become particularly significant when educational information is intended to support external labor-market decisions.

Fifth, studies addressing technological adoption and institutional inequalities indicate that the potential benefits of intelligent analytical systems may depend on organizational readiness, technological infrastructure, and equitable access to digital resources.

Despite these contributions, the reviewed studies do not establish a direct empirical relationship between dashboard-enabled visibility of verified vocational competencies and improved sustainable employment outcomes among South African vocational graduates.

In particular, insufficient evidence is available to determine whether the external communication of structured competency data through intelligent dashboards reduces information asymmetry between graduates and employers, improves employment matching, or contributes to employment stability.

This research gap provides the rationale for integrating human capital theory and signaling theory into a unified conceptual framework.

Accordingly, the present study proposes the SVSE Pathway, which conceptualizes the relationship between vocational skills acquisition, dashboard-enabled skills visibility, reduced signaling friction, and sustainable employment.

The proposed framework represents a theoretical synthesis of existing research rather than an empirically validated causal model. Its potential contribution lies in identifying relationships that can be examined through subsequent empirical investigations.

Theoretical Framework

The theoretical framework of this study is grounded in two complementary economic perspectives: human capital theory and signaling theory. These theories provide an analytical foundation for examining the relationship between vocational education, graduates' competencies, labor-market information asymmetry, and sustainable employment outcomes.

Human capital theory explains how investments in education and training contribute to the development of productive knowledge and skills, while signaling theory examines how information about these competencies is communicated and interpreted in labor-market interactions. Their integration enables a distinction between the actual acquisition of vocational competencies and the mechanisms through which employers recognize and evaluate them.

This distinction is particularly relevant to the present study because the development of industry-relevant skills does not necessarily guarantee that employers possess sufficient information to assess graduates' capabilities. Furthermore, the availability of detailed competency information does not, on its own, ensure successful employment outcomes, which also depend on labor-market demand and institutional conditions.

Accordingly, integrating human capital theory and signaling theory provides a conceptual foundation for examining the potential role of intelligent data visualization dashboards in enhancing the visibility and credibility of vocational competencies. These theoretical relationships subsequently inform the development of the SVSE Pathway.

1. Human Capital Theory

Human capital theory, developed by Becker (1964), conceptualizes education and training as investments in individuals' productive capabilities. According to this perspective, the acquisition of knowledge, practical skills, and professional competencies may increase individual productivity and generate economic returns through improved employment opportunities and higher earnings.

Applied to vocational education in South Africa, this theoretical approach suggests that TVET colleges and vocationally oriented higher education programs can enhance graduate employability by developing competencies aligned with labor market requirements.

Vocational education is particularly important in this context because it emphasizes acquiring occupation-specific skills that support productive participation in economic activities. However, the effectiveness of vocational training depends on several interrelated conditions, including curriculum relevance, educational quality, institutional resources, industry cooperation, and the availability of suitable employment opportunities.

The reviewed literature indicates that vocational education systems in South Africa and the broader Sub-Saharan African region continue to face challenges related to skills mismatches, institutional capacity constraints, and insufficient alignment between training outcomes and employers' requirements (Mayombe, 2021; Moloto et al., 2025).

These findings suggest that investment in vocational education does not automatically result in sustainable employment. Graduates may acquire relevant competencies yet encounter difficulties securing employment due to structural labor-market constraints, limited occupational opportunities, or insufficient recognition of their actual capabilities.

From the perspective of human capital theory, the economic value of vocational education is therefore associated not only with the formation of productive competencies but also with the conditions under which these competencies are utilized in the labor market.

This interpretation provides an important theoretical distinction for the present study. While vocational education contributes to the development of human capital, additional mechanisms may

be required to improve the communication and recognition of acquired competencies among prospective employers.

Nevertheless, the existence of graduate unemployment or skills mismatches should not be interpreted as direct evidence that competency information is insufficient. Such outcomes may also result from limited labor demand, differences in training quality, and broader socioeconomic conditions.

Consequently, human capital theory provides the foundation for understanding the first stage of the proposed SVSE Pathway, namely vocational skills acquisition, while also highlighting the need to examine the conditions affecting the transformation of acquired competencies into sustainable employment outcomes.

2. Signaling Theory

Signaling theory, introduced by Spence (1973), provides a complementary explanation of labor-market interactions under conditions of information asymmetry. In recruitment processes, employers often have incomplete information about applicants' actual productivity, practical competencies, and suitability for specific occupational positions.

Educational qualifications and professional certifications may therefore function as observable signals that employers use to assess candidates when direct information about their productive capabilities is limited.

However, the effectiveness of such signals depends on their credibility, relevance, and capacity to distinguish between individuals with different levels of competence. Formal qualifications may indicate educational attainment without necessarily providing detailed evidence of specific practical skills or workplace readiness.

In vocational education, this distinction is particularly important because graduates may possess technical and occupation-specific competencies that are not fully represented by conventional educational credentials.

The South African context is well-suited to examining this issue, given the documented persistence of graduate skills mismatches and the challenges of aligning educational outcomes with labor-market requirements.

Nevertheless, these challenges cannot be attributed exclusively to information asymmetry. They may also reflect differences between acquired and required competencies, insufficient employment opportunities, and structural inequalities within the labor market.

Within this theoretical perspective, intelligent data visualization dashboards may offer an additional mechanism for communicating information about graduates' competencies to prospective employers.

By integrating and presenting verified information about practical training outcomes, professional certifications, demonstrated skills, and other relevant indicators, such dashboards could potentially provide employers with a more detailed basis for evaluating candidates than formal qualifications alone.

The potential contribution of dashboard technologies therefore lies in improving the accessibility, transparency, and interpretability of competency-related information.

From a signaling theory perspective, this functionality may reduce information asymmetry by enabling employers to assess a broader range of observable indicators associated with graduates' capabilities.

However, the availability of additional information does not automatically improve the reliability of labor-market signals. Dashboard effectiveness would depend on the validity of competency assessments, the accuracy of underlying data, the credibility of verification procedures, and employers' willingness to use the information in recruitment decisions.

Furthermore, the external communication of educational data requires appropriate safeguards concerning privacy, consent, transparency, and responsible information governance.

Accordingly, this study considers dashboard-enabled skills visibility as a theoretically plausible mechanism for reducing signaling friction between vocational graduates and employers.

The proposed relationship remains a conceptual proposition rather than an empirically established causal effect. Further research is therefore required to determine whether providing verified competency information through intelligent dashboards improves employment matching and contributes to sustainable graduate employment.

3. Towards an Integrated Theoretical Lens

The integration of human capital theory and signaling theory offers a comprehensive conceptual framework for examining the relationship among vocational education, competency recognition, and sustainable employment.

Human capital theory emphasizes the acquisition of productive knowledge and skills through education and training, whereas signaling theory focuses on the communication and interpretation of information about these competencies within the labor market.

Together, these perspectives suggest that successful labor-market integration depends on two distinct yet interconnected processes: the development of relevant vocational competencies and the availability of credible mechanisms for employers to assess them.

Within this integrated theoretical framework, intelligent data visualization dashboards may serve as an intermediary information mechanism that connects vocational education outcomes with employers' recruitment requirements.

The proposed mechanism involves transforming institutional competency-related data into structured, accessible, and potentially verifiable information that can support the assessment of graduates' suitability for employment opportunities.

This process may help reduce information asymmetry and improve the quality of graduate-employer matching, provided that the information presented is accurate, relevant, and trusted by labor-market participants.

Nevertheless, the proposed relationship is conditional rather than deterministic. Improved competency visibility cannot compensate for the absence of suitable employment opportunities or deficiencies in the actual skills acquired through vocational education.

Similarly, dashboard implementation may be constrained by institutional resources, technological infrastructure, organizational culture, data governance requirements, and inequalities between higher education institutions.

These considerations indicate that the potential employment-related benefits of intelligent dashboards should be examined within a broader institutional and socioeconomic context.

The integration of human capital theory and signaling theory therefore provides the theoretical basis for the SVSE Pathway.

The proposed conceptual model comprises four interrelated stages: vocational skills acquisition, dashboard-enabled skills visibility, reduced signaling friction, and sustainable employment.

The first stage concerns the development of productive competencies through vocational education. The second involves the structured presentation and verification of information about these competencies. The third represents the potential reduction of information asymmetry between graduates and employers, while the fourth concerns the achievement of durable employment outcomes aligned with graduates' acquired skills.

Importantly, the relationships between these stages represent theoretically derived propositions that require empirical examination rather than confirmed causal relationships.

Accordingly, the integrated theoretical framework provides an analytical foundation for the systematic synthesis of existing evidence and the subsequent development of the SVSE Pathway as the principal conceptual contribution of this study.

Materials and Methods

This study employed a systematic literature review (SLR) approach, supported by narrative thematic synthesis, to examine the relationship between vocational education, graduate skills mismatches, intelligent data visualization dashboards, and sustainable employment in South African higher education.

The review was designed to integrate evidence from two interconnected research areas: graduate skills development and employment outcomes, and the application of intelligent dashboards to educational and institutional decision-making.

The study reports its identification and selection process using a PRISMA-informed framework. However, the completeness of its reporting against the PRISMA 2020 checklist depends on verification of the original search records, eligibility decisions, and quality appraisal procedures.

1. Research Questions and Eligibility Criteria

The review focused on three interconnected analytical questions:

1. What does the existing literature reveal about graduate skills mismatches and sustainable employment challenges in South African vocational and higher education?
2. What capabilities and institutional limitations characterize the application of intelligent data visualization dashboards in higher education?
3. How might dashboard-enabled visibility of verified vocational competencies contribute to reducing information asymmetry and improving graduate-employer matching?

The eligibility criteria were defined to identify literature relevant to these questions.

Sources were considered eligible if they addressed at least one of the following areas: graduate skills mismatches, vocational education or TVET, or intelligent data visualization dashboards applied to institutional or labor-market decision-making.

Priority was given to evidence concerning South Africa, particularly studies examining graduate employment, vocational education, institutional analytics, and educational technology adoption.

The review covered publications from 2011 to 2026 and included English-language peer-reviewed journal articles, systematic literature reviews, and reputable institutional case studies.

Studies addressing dashboards or skills mismatches without direct relevance to South Africa were considered when their findings offered transferable insights or foundational conceptual perspectives.

Sources without sufficient relevance to the research questions were excluded from the review.

The distinction between studies included in the evidence synthesis and publications used primarily for theoretical or contextual grounding requires verification against the original selection records.

2. Search Strategy

The literature search was organized around two thematic clusters.

The first cluster addressed vocational education, graduate skills mismatches, unemployment, and sustainable employment. The second focused on intelligent data visualization dashboards, educational analytics, and institutional decision-making.

According to the original methodological description, structured searches were conducted across Scopus- and Web of Science-indexed journals and sources accessible through the South African Journal of Information Management, SAGE, Springer, and the Directory of Open Access Journals (DOAJ).

The search employed combinations of the following terms: “vocational education”, “TVET”, “skills mismatch”, “graduate unemployment”, “sustainable employment”, “dashboard”, “data visualization”, and “South Africa”.

Searches were conducted iteratively to identify publications addressing the individual

thematic clusters and their potential intersections.

The identified literature was subsequently examined to determine whether existing studies directly examined the relationship between dashboard-enabled visibility of vocational skills and sustainable graduate employment.

For full reproducibility, the final manuscript should report the exact search dates, search strings, search fields, and database-specific restrictions. These details are not sufficiently documented in the original methodological description and should be verified against the authors' search records.

3. Study Selection and Quality Appraisal

The study-selection process comprised an initial screening of titles and abstracts, followed by full-text assessment of potentially relevant publications.

During screening, priority was given to systematic literature reviews and empirical studies addressing South African educational and labor-market conditions. International studies were considered where their findings were relevant to the analytical framework or potentially transferable to the South African context.

The original manuscript reports that 27 sources satisfied the inclusion criteria and were retained for the review.

The accompanying PRISMA flow diagram reports 1,642 identified records; 819 duplicate records removed; 823 records screened; 718 records excluded during screening; and 105 full-text reports assessed for eligibility.

The relationship between the full-text eligibility decisions, the separately reported quality exclusions, and the final set of 27 included sources requires reconciliation.

Although the original section refers to quality appraisal, it does not specify a formal appraisal instrument, scoring procedure, or study-level quality results.

Consequently, the final methodological report should distinguish between relevance-based selection and formal assessment of methodological quality. A formal quality appraisal should be reported only if it was actually conducted and supported by identifiable assessment records.

The study identification, screening, eligibility assessment, and inclusion procedures are presented in Figure 1.

4. Data Synthesis

Given the heterogeneity of the included publications, a narrative thematic synthesis approach was adopted.

The reviewed literature comprised systematic reviews, empirical studies of graduate employment and labor market conditions, research on vocational education, and institutional case studies on educational analytics and dashboard technologies.

The original study describes an inductive thematic coding process in which findings were organized around the research questions and interpreted through the theoretical perspectives established in the preceding section.

The synthesis focused on relationships between vocational competency development, graduate skills mismatches, dashboard capabilities, institutional adoption constraints, and sustainable employment.

Human capital theory and signaling theory were employed as complementary interpretative perspectives. Human capital theory informed the analysis of competency acquisition, while signaling theory supported the examination of information asymmetry between graduates and employers.

The findings were integrated to identify the extent to which existing research supports a conceptual relationship between dashboard-enabled competency visibility and graduate employment outcomes.

This synthesis provided the basis for developing the SVSE Pathway.

The proposed pathway should be interpreted as a conceptual synthesis of the reviewed evidence rather than an empirically validated causal model.

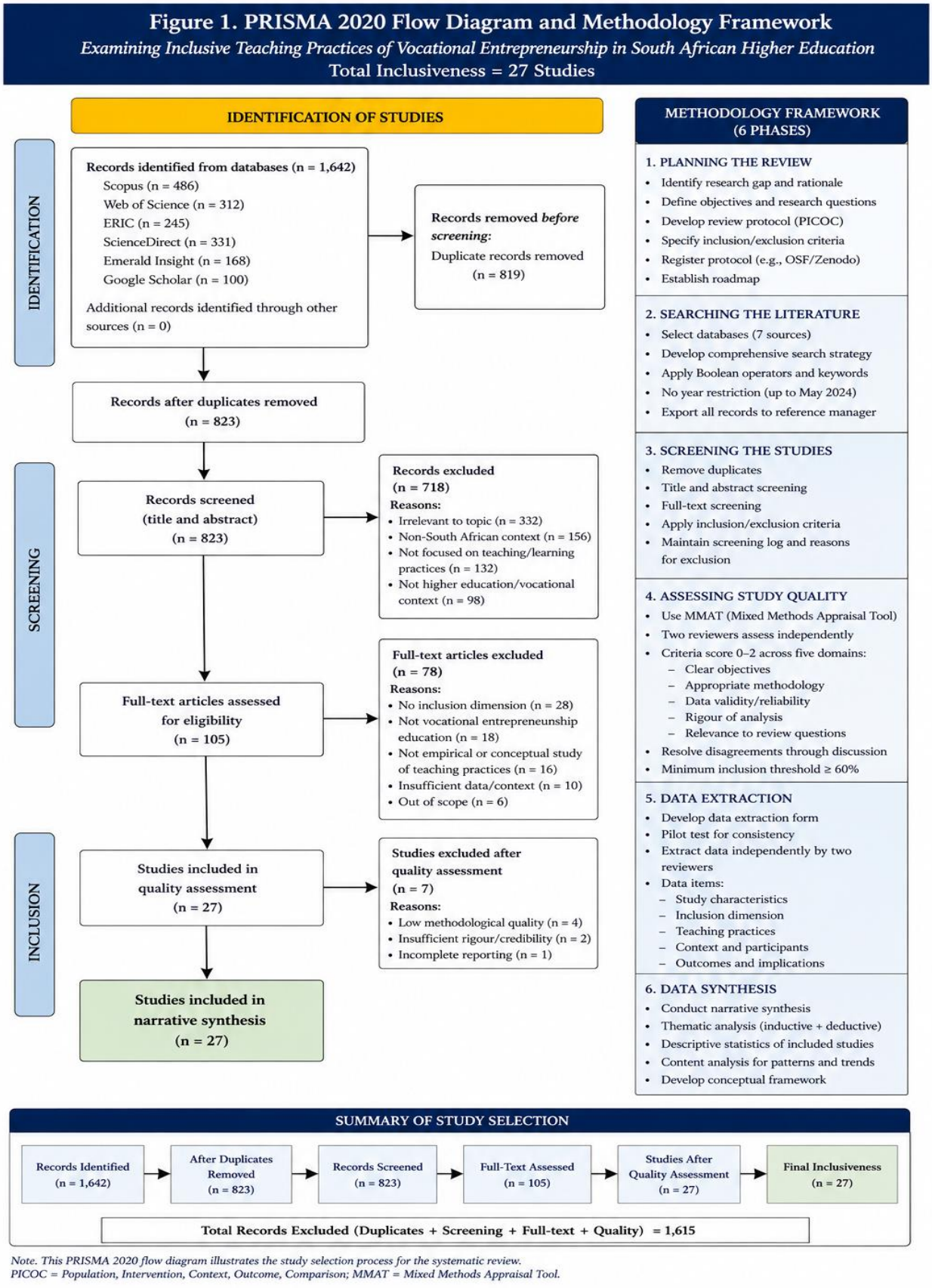


Figure 1. PRISMA flow diagram of the study selection process
Source: Developed by the authors based on the PRISMA 2020 framework.

Results

The systematic literature review identified several interconnected research themes concerning vocational education, graduate employability, intelligent data visualization dashboards, and the institutional conditions that affect their implementation in South African higher education.

The findings are organized into three analytical components: the characteristics of the reviewed literature, the principal thematic findings, and the positioning of the present study relative to previous research.

The synthesis draws on the 27 publications listed in Table 1. These sources address different but related aspects of graduate skills development, employment outcomes, educational analytics, institutional governance, and digital transformation.

1. Characteristics of the Reviewed Literature

The reviewed publications cover the period from 2011 to 2026 and represent several interconnected areas of research.

The first area concerns graduate unemployment, skills mismatches, vocational education, and labor-market alignment. These studies examine the relationship between educational outcomes and employment opportunities, highlighting structural constraints affecting graduates' transition into the labor market.

The second area addresses intelligent dashboards, learning analytics, business intelligence, and data-driven decision-making in higher education. The reviewed studies demonstrate the development of analytical technologies for monitoring educational processes, supporting institutional management, and improving access to decision-relevant information.

The third area concerns institutional adoption, digital transformation, ethical governance, data privacy, and inequalities in technological capabilities. These publications identify contextual conditions that may influence the implementation and effectiveness of intelligent analytical systems.

The fourth area examines entrepreneurship education, work-integrated learning, inclusive educational practices, and the development of competencies relevant to graduate employability.

Table 1 presents the characteristics and principal contributions of the publications included in the review.

Table 1. Characteristics of the sources included in the systematic review

	Study	Thematic Focus	Key Contribution
1	Moloto, Ramasimu, Motsei & Muchie (2025)	Graduate unemployment and skills mismatch in South Africa	Finds that structural mismatch between education output and labor-market demand drives persistent graduate unemployment
2	Mncayi & Dunga (2016)	Career choice and unemployment duration	Finds field-of-study/labour-market misalignment lengthens unemployment duration
3	Mncayi & Meyer (2022)	Perceived underemployment among young graduates	Identifies determinants of underemployment perception distinct from unemployment itself
4	Mayombe (2021)	Vocational education and training in Sub-Saharan Africa	Synthesizes VET's role and structural constraints across the Sub-Saharan African region
5	Chomunorwa (2026)	Barriers to data-driven decision-making in South African HEIs	Finds that a hierarchical governance culture limits translation of institutional data into practice

	Study	Thematic Focus	Key Contribution
6	Nyalungu (2011)	Business intelligence for strategic planning in higher education	Demonstrates an early working BI framework for institutional strategic decisions
7	Curran, Carlo & Harris-Walls (2026)	Systems-level data dashboards for leadership and policy	Finds dashboards enable policy visibility but can narrow what counts as meaningful via chosen metrics
8	Cabral et al. (2025)	AI-powered learning analytics dashboards	Identifies institutional decision-making as a primary dashboard application domain
9	Maimela & Mbonde (2025)	AI adoption and institutional stratification in South African universities	Finds historically advantaged universities outpace historically disadvantaged ones in technology adoption
10	Ajoodha, Jadhav & Dukhan (2020)	Predictive analytics for student retention	Demonstrates ML-based attrition forecasting usable as dashboard input at a South African university
11	Paulsen & Lindsay (2024)	Learning analytics dashboards and student learning	Demonstrates the shift from dashboards primarily focused on displaying analytics to dashboards designed to actively support learning, reflection, and student engagement.
12	Kaliisa, Jivet & Prinsloo (2023)	Design and evaluation of learning analytics dashboards	Provides a practical checklist covering the planning, design, implementation and evaluation of learning analytics dashboards, supporting more systematic and user-centered dashboard development.
13	Schwendimann et al. (2017)	Learning dashboard visualization	Provides a foundational systematic review of learning dashboards, examining their purposes, data sources, visualizations, users and reported effects on teaching and learning.
14	Gumbs et al. (2026)	Entrepreneurial competencies and inclusive education.	Emphasizes developing entrepreneurial competencies through inclusive and accessible education.
15	Ifenthaler & Yau (2020)	Learning analytics and student success	Shows how learning analytics can support study success in higher education through early identification of students' needs, monitoring and data-informed interventions.
16	Bergdahl et al. (2024)	Student engagement and learning analytics	Synthesizes evidence on how learning analytics relates to student engagement and highlights the importance of meaningful interpretation and student involvement in analytics-supported learning.
17	Rienties et al. (2023)	Education 4.0 and digital transformation	Examines the development of Education 4.0 in higher education and highlights the growing importance of digital technologies, data-driven learning and future-oriented skills.

	Study	Thematic Focus	Key Contribution
18	Prinsloo, Khalil & Slade (2024)	Learning analytics and data ecology	Conceptualizes learning analytics as part of a broader data ecology involving people, technologies, institutions, policies and data practices, highlighting the need for contextualized analytics.
19	Prinsloo (2019)	Educational analytics and institutional power	Critically examines analytics as a form of institutional practice and highlights issues of power, agency, interpretation and the consequences of data-driven educational decision-making.
20	Prinsloo (2022)	Data privacy and African learning analytics	Examines data privacy challenges and opportunities within the African context and emphasizes responsible, ethical and context-sensitive use of learner data in learning analytics.
21	Sivasanker & Beharry-Ramraj (2026)	Bridging theory and practice in South African universities.	Highlights practical and experiential learning to strengthen entrepreneurial skills.
22	Prinsloo & Slade (2019)	Ethics and student data	Traces the development of ethical thinking regarding student data and highlights the importance of privacy, transparency, responsibility, and ethical governance in the use of educational analytics.
23	Kana & Letaba (2024)	TVET, 4IR skills and employment prospects	Examines curriculum transformation in South African TVET colleges and emphasizes the need to develop 21st-century competencies that improve graduates' employment prospects.
24	Paterson, Herholdt, Keevy & Akoobhai (2021)	Work-based values and youth employability	Highlights work-based values as an important but often overlooked component of youth employability and emphasizes stronger connections between vocational education and workplace expectations.
25	Nduna (2026)	Work-integrated learning and South African colleges	Identifies barriers to effective work-integrated learning in South African colleges, highlighting challenges that affect students' transition from education to employment.
26	Funda & Mbangeleli (2024)	AI in South African higher education	Explores AI as a tool for addressing academic challenges in South African higher education and demonstrates the emerging potential of AI-enabled approaches for improving educational processes and outcomes.
27	Owusu-Acheampong et al. (2025)	Effectiveness of entrepreneurship education in Sub-Saharan Africa.	Identifies institutional, curricular, resource, and teaching factors that influence entrepreneurship education.

Source: Compiled by the authors based on the reviewed literature.

The diversity of the reviewed publications demonstrates the interdisciplinary nature of the research problem. However, differences in study design, institutional context, and analytical objectives limit the possibility of treating the identified findings as directly comparable measures of employment-related effects.

Accordingly, the results are interpreted through narrative thematic synthesis rather than quantitative meta-analysis.

2. Principal Findings of the Thematic Synthesis

The synthesis identified five principal findings.

First, graduate skills mismatches remain a persistent challenge in South Africa. The reviewed studies identify discrepancies between educational qualifications, acquired competencies, and labor-market requirements. These discrepancies are associated with graduate unemployment, underemployment, and difficulties in securing employment aligned with educational preparation.

Second, vocational education contributes to competency development but faces structural and institutional limitations. Research on vocational education and training highlights the importance of curriculum relevance, practical training, industry partnerships, and quality assurance. These factors influence the extent to which educational outcomes correspond to occupational requirements.

Third, intelligent dashboards provide established capabilities for educational data analysis and institutional decision-making. The reviewed publications document applications involving performance monitoring, learning analytics, predictive modeling, and strategic management. Nevertheless, these applications primarily concern educational and institutional processes rather than the external communication of verified vocational competencies to employers.

Fourth, the implementation of intelligent analytical systems is influenced by institutional and ethical conditions. The literature identifies organizational culture, technological infrastructure, resource availability, data governance, privacy, and institutional inequalities as relevant factors affecting technology adoption and utilization.

Fifth, graduate employability is shaped by competencies and conditions extending beyond formal qualifications. Research on entrepreneurship education, work-integrated learning, and professional development emphasizes the relevance of practical experience, workplace expectations, and transferable competencies.

Taken together, these findings indicate that the reviewed literature provides substantial evidence concerning vocational skills development and dashboard capabilities as separate research areas.

However, the reviewed studies do not establish whether integrating these areas through dashboard-enabled competency visibility produces measurable improvements in graduate-employer matching or sustainable employment outcomes.

5.3. Positioning the Present Study Relative to Previous Research

The reviewed literature demonstrates that graduate skills mismatches and intelligent dashboard technologies have generally been investigated from different disciplinary perspectives.

Research on graduate employment primarily examines educational alignment, labor market conditions, and determinants of employability. In contrast, studies of intelligent dashboards focus predominantly on institutional management, learning analytics, educational performance, and decision-support capabilities.

Table 2 summarises the positioning of the present study relative to selected publications representing these research areas.

Table 2. Positioning the present study relative to previous research

Prior Source	Examines Graduate Skills Mismatch?	Examines Dashboard Capability?	Connects the Two Directly?
Moloto et al. (2025) — SA graduate mismatch SLR	Yes	No	No
Mayombe (2021) — VET in Sub-Saharan Africa	Yes	No	No
Curran, Carlo & Harris-Walls (2026) — dashboard SLR	No	Yes	No
Chomunorwa (2026) — SA data-driven decision barriers	No	Yes (institutional)	No
This review	Yes	Yes	Yes — via the proposed SVSE Pathway

Source: Compiled by the authors based on the reviewed literature.

The comparison indicates that the selected studies primarily examine either graduate skills mismatches or dashboard capabilities, while the present review explicitly considers their potential relationship.

This integration constitutes the study's conceptual orientation rather than evidence that dashboard-enabled skills visibility has already improved employment outcomes.

The principal research gap concerns the lack of direct empirical evidence in the reviewed sources linking the external visualization of verified vocational competencies to reduced information asymmetry and sustainable employment among South African graduates.

The identified gap provides the foundation for the conceptual synthesis developed in the following section.

The proposed SVSE Pathway integrates vocational skills acquisition, dashboard-enabled competency visibility, reduced signaling friction, and sustainable employment within a single theoretical structure.

Its proposed relationships require subsequent empirical examination to establish their validity, magnitude, and applicability across different institutional and labor-market contexts.

Discussion

The findings of this systematic literature review are discussed in relation to the theoretical framework and the evidence presented in the preceding sections. Particular attention is given to the relationships among vocational skills development, graduate employability, intelligent data-visualization dashboards, and labor-market information asymmetry.

The discussion addresses the research questions by integrating findings from the literature on graduate skills mismatches and dashboard technologies. It subsequently introduces the SVSE Pathway and examines its potential implications for institutional practice in South African higher education.

1. Synthesis Against Theory and Literature

The reviewed literature indicates that graduate skills mismatches remain a persistent challenge within South Africa's higher education and labor-market systems. Existing studies identify discrepancies between graduates' educational preparation and occupational requirements, as well as prolonged unemployment and underemployment, as important dimensions of this problem

(Mncayi & Dunga, 2016; Mncayi & Meyer, 2022; Moloto et al., 2025).

Research on vocational education further demonstrates that the development of occupation-specific competencies does not necessarily ensure successful labor-market integration. Institutional resources, curriculum relevance, educational quality, and industry partnerships influence the effectiveness of vocational education in preparing graduates for employment (Mayombe, 2021).

From the perspective of human capital theory, vocational education represents an investment in productive knowledge and skills. However, the economic benefits of this investment depend on the extent to which the acquired competencies align with labor-market requirements and can be effectively utilized in employment.

The persistence of graduate skills mismatches therefore suggests limitations in the relationship between educational preparation and labor-market outcomes. Nevertheless, it does not establish that insufficient communication of competencies is the principal cause of graduate unemployment.

In parallel, the reviewed literature demonstrates the development of intelligent data visualization dashboards as instruments for institutional management, learning analytics, performance monitoring, and evidence-informed decision-making.

Nyalungu (2011) documents an early application of business intelligence in South African higher education, while Curran et al. (2026) and Cabral et al. (2025) examine the capabilities and applications of educational dashboards in broader institutional contexts.

These studies indicate that dashboard technologies can support the integration, interpretation, and presentation of complex educational information.

However, their documented applications primarily concern internal institutional decision-making rather than the external communication of vocational competencies to employers.

Signaling theory provides a complementary perspective for interpreting this distinction. According to Spence (1973), labor-market interactions may be characterized by information asymmetry because employers cannot directly observe all relevant characteristics of prospective employees.

Educational qualifications may function as signals of competence, but they do not necessarily provide detailed information about practical skills, workplace experience, or occupation-specific capabilities.

In this context, intelligent dashboards could supplement conventional educational credentials by presenting structured, verifiable competency information.

Such an application may improve employers' access to information about graduates' capabilities and support more informed recruitment decisions.

Nevertheless, the effectiveness of this mechanism depends on several conditions, including the validity of competency assessments, the reliability of institutional data, the credibility of verification procedures, and employers' willingness to use dashboard-generated information.

Furthermore, improved competency visibility cannot independently resolve structural labor-market constraints or compensate for deficiencies in the competencies themselves.

The central theoretical contribution of this review, therefore, lies in identifying dashboard-enabled visibility of vocational skills as a potentially relevant yet insufficiently investigated mechanism linking human capital development to labor-market signaling.

The reviewed evidence supports the conceptual plausibility of this relationship but does not establish its causal effect on sustainable employment outcomes.

2. The Skills-Visibility-to-Sustainable-Employment Pathway

To integrate the findings of the systematic literature review with human capital theory and signaling theory, this study proposes the SVSE Pathway.

The proposed framework conceptualizes a sequence of four interconnected stages through

which vocational competencies may be developed, communicated, interpreted, and potentially translated into sustainable employment outcomes.

Stage 1. Vocational Skills Acquisition

The first stage concerns the development of vocational knowledge, practical skills, and occupation-specific competencies through formal education, professional training, and work-integrated learning.

This stage is grounded in human capital theory, which explains how education and training contribute to individuals' productive capabilities.

Vocational curricula are intended to develop competencies relevant to labor-market requirements. However, the effectiveness of this process depends on educational quality, curriculum relevance, institutional resources, and industry collaboration.

Evidence from the reviewed literature indicates that competency acquisition represents a necessary but insufficient condition for sustainable graduate employment (Mayombe, 2021; Moloto et al., 2025).

Stage 2. Dashboard-Enabled Skills Visibility

The second stage involves the application of intelligent data visualization dashboards to organize, analyze, and present information about graduates' acquired competencies.

Unlike conventional dashboards designed primarily for institutional administration, the proposed application focuses on communicating verified competency-related information to prospective employers.

Relevant information may include educational achievements, practical training results, professional certifications, demonstrated technical competencies, and work-integrated learning outcomes.

The technological feasibility of educational data integration and visualization is supported by existing research on business intelligence, learning analytics, and institutional dashboards (Nyalungu, 2011; Curran et al., 2026; Cabral et al., 2025).

However, the application of these technologies specifically to external vocational skills signaling remains insufficiently examined in the reviewed literature.

Stage 3. Reduced Signaling Friction

The third stage concerns the potential reduction of information asymmetry between vocational graduates and employers.

By providing access to structured and credible competency information, intelligent dashboards may enable employers to assess applicants' practical capabilities more comprehensively than through formal qualifications alone.

From the perspective of signaling theory, this mechanism could strengthen the informational value of educational credentials and support more informed recruitment decisions.

Nevertheless, the anticipated reduction in signaling friction remains a theoretical proposition.

Its realization would depend on the accuracy, relevance, credibility, and accessibility of the information presented, as well as employers' acceptance of dashboard-based competency indicators.

Stage 4. Sustainable Employment

The fourth stage concerns the potential achievement of durable employment outcomes aligned with graduates' acquired competencies.

Within the proposed framework, sustainable employment involves more than obtaining an initial job. It also encompasses the correspondence between occupational requirements and graduates' skills, the effective utilization of competencies, and employment continuity.

Improved competency visibility may contribute to these outcomes by supporting better-informed graduate-employer matching.

However, sustainable employment is influenced by additional factors, including labor-market demand, economic conditions, employment opportunities, institutional inequalities, and individual circumstances.

Consequently, the proposed pathway should not be interpreted as establishing a direct or inevitable causal relationship between dashboard implementation and sustainable employment.

The four stages are presented in Figure 2.

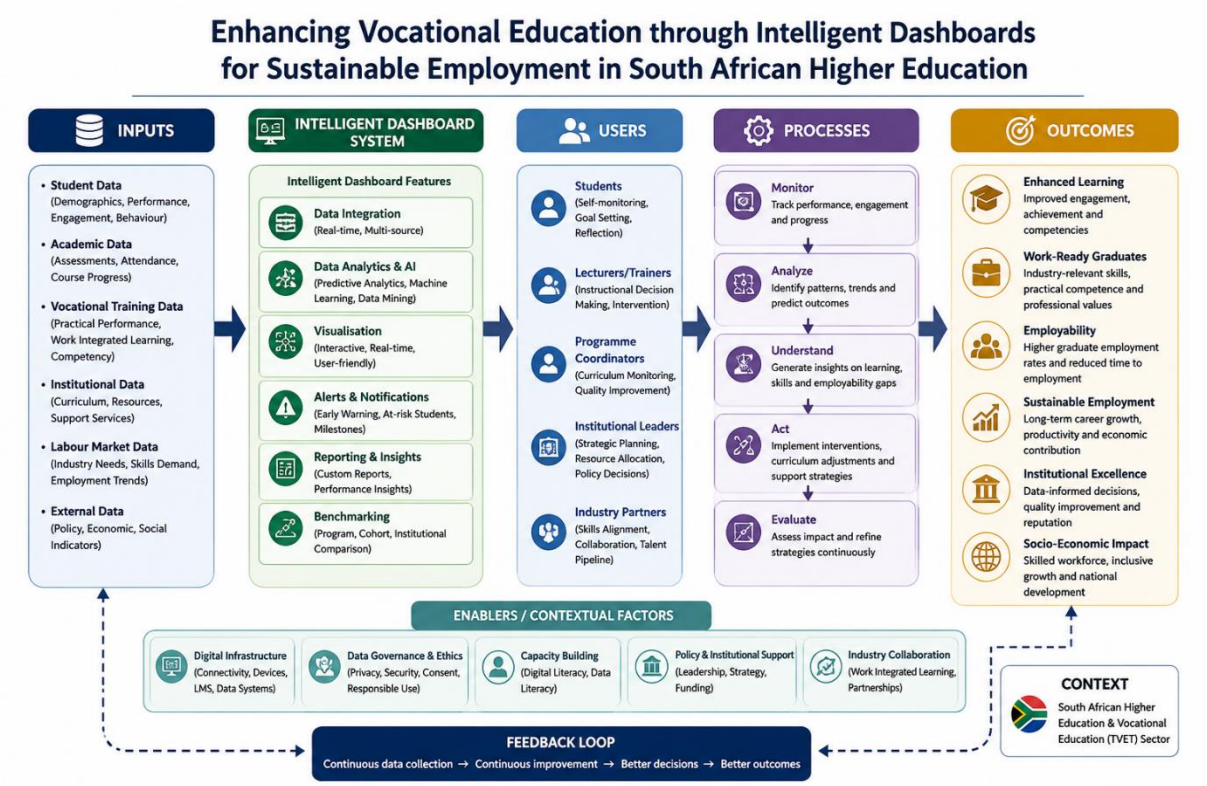


Figure 2. The Skills-Visibility-to-Sustainable-Employment Pathway, showing the four stages linking the acquisition of vocational skills to sustainable employment outcomes.

Source: Developed by the authors.

The proposed framework illustrates how intelligent data visualization dashboards can transform educational and employment-related data into information relevant to vocational education and labor market decision-making.

The dashboard may integrate information generated by students, academic staff, vocational education and training providers, higher education institutions, and industry stakeholders.

Through analytical and visualization technologies, potentially supported by artificial intelligence, the system could identify patterns in educational performance, competency deficiencies, and employment trends.

These analytical capabilities may support the monitoring, analysis, interpretation, implementation of interventions, and evaluation of educational and employment-related outcomes.

Relevant stakeholders include students, academic staff, vocational program coordinators, institutional administrators, and employers.

The principal conceptual contribution of the SVSE Pathway lies in extending the potential application of institutional dashboard technologies towards external labor-market signaling.

Rather than limiting educational analytics to internal monitoring and management, the proposed framework considers how verified competency information could facilitate communication among educational institutions, graduates, and prospective employers.

However, this proposed mechanism requires empirical validation before its effectiveness can be established.

An additional consideration concerns institutional inequality.

Research on technological adoption in South African higher education indicates that historically advantaged institutions may possess greater resources and organizational capacities to implement advanced analytical systems (Maimela & Mbonde, 2025).

Consequently, dashboard-enabled skills visibility initiatives could reproduce or reinforce existing inequalities if their implementation disproportionately benefits institutions with stronger technological infrastructure.

Equitable access, institutional readiness, and responsible data governance should therefore be considered essential conditions for the practical development of the SVSE Pathway.

3. Implications for Institutional Practice

The findings of this review and the proposed SVSE Pathway have several implications for vocational education institutions, higher education administrators, policymakers, and industry stakeholders.

First, vocational and TVET institutions could explore developing intelligent dashboards that communicate verified vocational competencies to external employers.

Such systems would extend the application of educational analytics beyond internal institutional reporting towards supporting graduate employability and labor-market information exchange.

Second, the development of dashboard-enabled competency visibility mechanisms should be based on reliable assessment procedures and clearly defined competency indicators.

The credibility of the information presented is essential, as inaccurate or poorly validated indicators can create misleading signals and undermine employers' confidence in the system.

Third, institutions should evaluate the effectiveness of these technologies using employment-related outcomes rather than relying exclusively on system usage, user satisfaction, or technical performance indicators.

Relevant evaluation dimensions may include employers' perceptions of competency information, graduate-employer matching, time to employment, occupational alignment, and employment continuity.

Fourth, policymakers and funding organizations should consider the potential implications of unequal adoption of technology across South African higher education institutions.

Pilot initiatives involving historically disadvantaged institutions could help determine whether dashboard-enabled competency visibility can be implemented under different resource and organizational conditions.

Fifth, institutional implementation should incorporate appropriate safeguards concerning personal data protection, informed consent, access rights, transparency, and accountability.

These requirements are particularly important when educational information is intended for external use by employers and other labor-market stakeholders.

Finally, cooperation between vocational education institutions and employers is necessary to determine which competency indicators are relevant, understandable, and useful for recruitment decisions.

Such cooperation may also support the development of more consistent approaches to competency assessment and the communication of vocational learning outcomes.

Taken together, these implications suggest that the potential value of intelligent dashboards extends beyond their technological capabilities.

Their contribution to sustainable graduate employment would depend on the interplay among educational quality, reliable competency information, institutional capacity, responsible governance, and labor market conditions.

Accordingly, the proposed SVSE Pathway provides a conceptual basis for future institutional experimentation and empirical research rather than a validated intervention ready for general implementation.

Conclusion

This systematic literature review examined the relationship between vocational education, graduate skills mismatches, intelligent data visualization dashboards, and sustainable employment in South African higher education. Drawing on human capital theory and signaling theory, the study integrated findings from two research areas that have largely developed independently: graduate employability and the application of dashboard technologies to educational and institutional decision-making.

The review identified persistent challenges related to graduate skills mismatches, unemployment, underemployment, and the alignment of vocational competencies with labor market requirements. Although vocational education contributes to the development of occupation-specific knowledge and skills, the successful transition from education to sustainable employment depends on additional institutional, economic, and labor-market conditions.

The reviewed literature also demonstrates that intelligent data visualization dashboards have established applications in educational analytics, performance monitoring, and institutional decision-making. However, their potential role in communicating verified vocational competencies to prospective employers has been insufficiently examined in the sources included in this review.

The principal conceptual contribution of the study is the proposed SVSE Pathway, which integrates four interconnected stages: vocational skills acquisition, dashboard-enabled skills visibility, reduced signaling friction, and sustainable employment.

The framework extends the application of human capital and signaling theories by considering how institutional competency data can be transformed into credible labor-market information. It suggests that intelligent dashboards could potentially improve the visibility of graduates' capabilities and support more informed employer recruitment decisions.

Nevertheless, the proposed relationships are theoretically derived and have not been empirically validated. Improved access to competency information does not necessarily eliminate skills mismatches or guarantee sustainable employment, particularly where labor-market demand, educational quality, or institutional resources remain inadequate.

The findings also highlight the importance of equitable technological implementation. Historically disadvantaged South African institutions may encounter greater financial, organizational, and infrastructural barriers to adopting intelligent dashboard systems. Consequently, initiatives intended to improve the visibility of graduate skills should take into account institutional inequality, accessibility, and responsible data governance.

The study has several limitations. Although Table 1 identifies 27 reviewed publications, the final number of studies included in the evidence synthesis needs to be reconciled with the original selection and quality-appraisal records. The reviewed publications also differ in their methodological approaches, institutional contexts, and analytical objectives, limiting the generalizability of their findings.

Furthermore, some studies are based on individual institutional settings, while others examine broader educational systems or international experiences. Their findings may therefore not be directly transferable to the diverse vocational education landscape of South Africa.

Most importantly, the proposed relationship between dashboard-enabled competency visibility, reduced information asymmetry, and sustainable employment remains a conceptual inference rather than an empirically demonstrated effect.

Future research should prioritize empirical pilot studies examining whether access to dashboard-verified vocational competency information improves employer confidence, graduate-

employer matching, and employment outcomes compared with conventional qualification-based recruitment practices.

Comparative research should also investigate the implementation of such systems across historically advantaged and disadvantaged institutions to assess their potential implications for educational and labor-market inequality.

Overall, the study provides a conceptual foundation for examining intelligent data visualization dashboards as a potential mechanism connecting vocational competency development with labor-market information exchange. The SVSE Pathway offers a structured basis for future empirical investigation, institutional experimentation, and the development of evidence-informed approaches to sustainable graduate employment in South Africa.

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Competing interests

The authors declare that they have no competing interests.

Use of Artificial Intelligence

Artificial intelligence was used for language editing, translation, and technical verification of the manuscript.

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