



Developing work readiness through curriculum-embedded consultant–client project workflows in an undergraduate computing module

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Abstract

Graduate employability remains a central concern in computing education, where students are expected to move from academic learning into professional environments requiring technical, organisational, social and self-management capabilities. This study examines, from a Scholarship of Teaching and Learning perspective, changes in students' self-reported work readiness after participation in a curriculum-embedded consultant–client project workflow in an undergraduate computing module in Botswana. The module required student teams to elicit requirements, complete benchmarking activities, develop an e-learning module, participate in structured meetings, prepare staged deliverables, demonstrate outputs to peer-client teams and submit final handover documentation. A within-cohort pre–post survey design was used. Self-reported work readiness was measured before and after the module using an adapted Work Readiness Scale. Thirty-two students with matched pre- and post-module responses were included in the final analysis. Wilcoxon signed-rank tests were used to compare pre- and post-module scores. Significant increases were found in organisational acumen, work competence, social intelligence and overall self-reported work readiness, while personal characteristics did not change significantly. Sensitivity analysis excluding one influential case showed that work competence, social intelligence and overall self-reported work readiness remained significant, while organisational acumen became a non-significant positive trend. The study provides practical guidance for computing educators by illustrating how professional project practices can be made explicit, structured and assessable within the curriculum.

Keywords

work readiness, curriculum-embedded employability learning, career development learning, structured consultant–client project workflow, computing education, project-based learning, Botswana

Introduction

Graduate employability is an important concern in higher education. Universities are increasingly expected to prepare graduates not only with disciplinary knowledge, but also with the broader capabilities needed to enter, adapt to and contribute within complex workplaces (Bridgstock, 2009; Jackson, 2016; Yorke, 2006). In computing education, this expectation is especially important because graduates often enter professional environments that require them to engage with clients, interpret

requirements, coordinate project tasks, document decisions, manage deadlines and deliver functional technology-based outputs.

This concern is particularly relevant in Botswana, where graduate employability is shaped by persistent labour-market and skills-alignment challenges. Statistics Botswana (2024) reported national unemployment of 27.6% and youth unemployment of 38.2% among those aged 15–35 in Quarter 1 of 2024. United Nations Development Programme Botswana (2025) similarly identifies youth employment as a central national development concern. The Priority Skills Report (Human Resource Development Council of Botswana, 2025) identifies sustained national demand for advanced digital and data-related occupations, including data scientists, data analysts, business intelligence analysts and artificial intelligence/machine learning specialists, across key economic sectors. Recent Botswana-based research also points to persistent mismatch between tertiary qualifications and labour-market requirements, as well as gaps in advanced cognitive abilities, socio-behavioural competencies and information technology proficiency among graduates (Munjevi & Schutte, 2024; Sebeelo, 2026). These concerns support curriculum-embedded employability learning that is visible, assessable and connected to workplace-like practice.

Computing curricula are well placed to respond to this challenge because computing project work can simulate many practices that graduates are likely to encounter in professional settings. However, conventional group assignments do not automatically produce employability learning. Students may complete group tasks without developing effective communication, coordination, documentation or client-facing habits. The educational problem, therefore, is not simply whether students complete projects, but how project work is structured to support work readiness and career development learning.

Project-based learning (PjBL), problem-based learning, authentic learning and work-integrated learning (WIL) approaches have been widely used to bridge academic learning and workplace practice (Ahmed et al., 2024; Herrington & Oliver, 2000; Hmelo-Silver, 2004; Jackson & O'Connor, 2026; Savery, 2006; Thomas, 2000). Yet the presence of a project is not sufficient by itself. Students also need structured processes that guide how they plan, communicate, coordinate, review progress, interact with clients, users and other project partners, and produce deliverables. In computing education, recent evidence suggests that structured project types, client involvement, mentoring arrangements and Agile-like iterative practices can shape students' self-rated career and professional readiness (Jillepalli et al., 2026a, 2026b; Sa'adah et al., 2026).

To our knowledge, the term 'structured consultant–client project workflow' has not previously been defined in the literature and is first introduced in this study to describe the specific learning design used. Hereafter, we use the shorter term 'the workflow' for consistency and concision. The concept nevertheless draws on related literature on collaboration scripts (Kollar et al., 2006; Weinberger et al., 2009), student consulting projects (Heriot et al., 2008; Podeschi, 2016), client-based capstone learning (Reifenberg & Long, 2017), authentic learning (Herrington & Oliver, 2000) and simulated PjBL (Hariyanto et al., 2026). In this study, it refers to a curriculum-embedded and assessed sequence in which student teams act as consultant teams or peer-client teams and undertake explicitly structured requirements elicitation, meetings, benchmarking, prototype review, feedback, documentation, demonstration and handover. The workflow differs from conventional client-based projects because its peer-client teams comprise students rather than representatives of external organisations. It is also distinguished from conventional PjBL because its professional roles, interaction routines, accountability points and assessment stages are explicitly prescribed. However, less is known about whether the workflow, when embedded within normal teaching and assessment, is associated with changes in specific dimensions of students' work readiness. The operational sequence of the workflow is presented in the Methodology section.

This study examines the workflow embedded in an undergraduate computing module at a public university in Botswana. The module required students to analyse, design, build, test and hand over an

e-learning module. Student teams worked through staged activities, including requirements elicitation, benchmarking, design and development, prototype review, user testing, final documentation and handover. The project was therefore not treated simply as group work, but as a curriculum-embedded employability-learning design supported by roles, meetings, staged deliverables, feedback points and formal documentation.

The study focuses on students' self-reported work readiness. Work readiness refers to graduates' perceived preparedness to enter and function effectively in workplace settings (Caballero et al., 2011). Recent work by Caballero et al. (2026) further clarifies that work readiness and graduate employability are related but distinct constructs. Employability is broader and future-oriented, whereas work readiness concerns more immediate preparedness to understand, integrate into and perform in workplace contexts (Caballero et al., 2026). Work readiness includes personal characteristics, organisational acumen, work competence and social intelligence.

The aim of this study is to examine how students' self-reported work readiness changed after participation in the workflow embedded in an undergraduate computing module. The study addresses the following research question: How did students' self-reported work readiness change after participation in the workflow embedded in an undergraduate computing module?

The study makes an original contribution to Scholarship of Teaching and Learning (SoTL) and curriculum-embedded employability learning in three ways. First, it examines work readiness in a Global South higher education context where more evidence is needed on employability learning. Second, it specifies the workflow in which professional roles, interaction routines, staged deliverables and assessment points are explicitly embedded within an undergraduate computing module, thereby identifying a pedagogical structure that other computing educators can adapt. Third, it uses self-reported work readiness as a multidimensional outcome for evaluating the workflow and provides pre–post evidence relevant to the development of specific work-readiness dimensions, showing which areas demonstrated the greatest change during the workflow. In doing so, the study positions self-reported work readiness as a proximal educational outcome that can indicate changes during the workflow. This differs from graduate employment outcomes measured after graduation, which are influenced by labour-market conditions and multiple personal, institutional and contextual factors beyond the workflow.

The remainder of the paper is structured as follows. The next section reviews literature on work readiness, curriculum-embedded employability learning and structured consultant–client project workflows in computing education. The methodology section describes the module context, research design, participants, adapted Work Readiness Scale (WRS), data collection and analysis procedures. The results section presents reliability estimates, descriptive pre–post changes, Wilcoxon signed-rank tests and sensitivity analysis. The discussion interprets the findings in relation to work readiness, the workflow and employability learning. The paper concludes with implications for computing educators, limitations and directions for future research.

Literature review

Conceptualising work readiness within curriculum-embedded employability learning

Employability is commonly understood as a combination of knowledge, skills, attributes and dispositions that enable graduates to obtain, sustain and succeed in employment (Bridgstock, 2009; Yorke, 2006). More recent work has also emphasised employability as a developmental process connected to professional identity, career self-management, social capital and the capacity to adapt to changing work contexts (Jackson, 2016). This perspective is important because employability is not only an individual possession or a graduate outcome measured after completion. It is also shaped by curriculum design, assessment and opportunities to practise workplace-relevant behaviours.

For this study, work readiness is treated as a more immediate and measurable dimension of curriculum-embedded employability learning. Caballero et al. (2011) developed the WRS to assess graduate work readiness across four dimensions: personal characteristics, organisational acumen, work competence and social intelligence. These dimensions capture personal attributes, organisational understanding, task-related competence and interpersonal capability.

Since the original WRS was developed, later work has reinforced the need to distinguish work readiness from broader graduate employability. Caballero et al. (2026) argue that work readiness refers more specifically to graduates' preparedness to understand, integrate into and perform in workplace contexts, whereas employability is broader and more future-oriented. Recent reviews and adaptations of work-readiness measures also show that WRS-based instruments can be used across professional and disciplinary contexts, but that adaptations should report item structure, response format and reliability (Lawton et al., 2023; Orr et al., 2023). This is relevant to the present study because it uses an adapted WRS to examine students' self-reported work readiness during the workflow.

The dimensions of work readiness encompass generic, transferable capabilities that support effective performance across professional contexts, including communication, teamwork, adaptability, responsibility, responsiveness to feedback and the ability to operate within organisational expectations (Caballero et al., 2011, 2026; Jackson, 2016; Orr et al., 2023). In computing education, these capabilities are enacted through discipline-specific practices such as participating in client meetings, interpreting user requirements, coordinating software or technology projects, using professional tools, documenting decisions and managing changing requirements (CC2020 Task Force, 2020; Jillepalli et al., 2026a, 2026b; Nasir et al., 2025; Sa'adah et al., 2026). Technical competence is therefore necessary but insufficient; computing graduates must also apply broader interpersonal, organisational and self-management capabilities within technology-focused work (CC2020 Task Force, 2020; Galster et al., 2023). Work readiness consequently provides a useful conceptual lens for examining students' perceived preparedness for the transition from academic learning to workplace-like computing practice.

Theoretical framing: authentic learning and collaboration scripts

This study draws on authentic learning and collaboration-script theory as complementary perspectives for understanding the workflow. Authentic learning emphasises tasks that resemble real-world practice, involve complexity, require collaboration and lead to meaningful outputs (Herrington & Oliver, 2000). From this perspective, the workflow can provide opportunities to practise workplace-like processes, such as requirements clarification, prototype review, documentation and handover, even when these activities occur within a classroom simulation. Authentic learning therefore explains why the workflow positioned students in professional roles and required them to produce meaningful, workplace-like outputs.

Collaboration-script theory explains how interaction within such workplace-like tasks can be deliberately structured. Collaboration scripts structure how learners interact, take roles, exchange information, sequence tasks and produce joint outputs (Kollar et al., 2006; Weinberger et al., 2009). In project-based computing education, structured workflows can therefore function as scripts that support coordination, accountability and professional communication through explicitly defined roles, meetings, activity sequences and deliverables.

Together, authentic learning explains the workplace-like character of the workflow, while collaboration-script theory explains how students' participation is structured through explicit roles, interactions and deliverables. These complementary perspectives jointly underpin the workflow examined in this study.

Empirical research on curriculum-embedded employability learning

Research on curriculum-embedded employability learning suggests that work readiness can be strengthened when students engage in activities that connect academic learning to professional practices. Jackson and O'Connor (2026), for example, show that WIL can help bridge discipline-specific teaching with work practices in Science, Technology and Mathematics disciplines. Their work is important for the present study because it recognises that WIL is not limited to external placements. It can also include non-workplace experiences such as class projects, consultancies, virtual projects and simulated work environments. This wider understanding makes it possible to conceptualise structured classroom project work as a form of curriculum-embedded employability learning.

Lambert et al. (2026) argue that authentic, industry-based assessments can help students move from knowledge acquisition towards work readiness and employability by building self-efficacy, professional identity and social capital. Wright et al. (2026) similarly emphasise the need for authentic learning to be embedded progressively, with realistic tasks, scaffolded support, collaboration and assessment practices that mirror professional evaluation. Together, these studies suggest that employability learning is strengthened when curriculum design gives students repeated opportunities to practise, reflect on and evidence workplace-like capabilities.

PjBL (Thomas, 2000) and problem-based learning (Hmelo-Silver, 2004; Savery, 2006) are widely used to support active and applied learning. However, their contribution to employability depends not only on the presence of a complex project, but also on whether professional expectations, interaction with clients and project partners, and work-like accountability are deliberately embedded in the project design. In this form, PjBL can function as a curriculum-based form of WIL by connecting academic tasks to professional practices and industry expectations. Ahmed et al. (2024) examined industry perspectives on PjBL as WIL and found that industry partners generally valued such projects, especially where they supported communication, attitude development and graduate skill formation. These findings reinforce the importance of deliberate design when classroom projects are intended to approximate workplace learning.

Simulated PjBL may also support employability when it exposes students to realistic briefs, deadlines, feedback, client and user expectations, and professional uncertainty (Hariyanto et al., 2026). Black and Warhurst (2025) similarly argue that workplace-equivalent experiences can be created inside the classroom when students are positioned in professional roles and required to solve realistic problems. Together, this literature establishes that employability learning depends on the purposeful simulation and structuring of professional practice rather than on project participation alone.

Structured consultant–client project workflows in computing education

Against this background, a structured consultant–client project workflow represents a specific form of curriculum-embedded employability learning informed by PjBL. Rather than assuming that students know how to manage projects, the workflow requires explicit routines such as role allocation, requirements elicitation, progress meetings, decision documentation, staged deliverables, peer-client reviews, prototype demonstrations and handover documentation. These routines make workplace-like processes visible and allow students to practise professional behaviours within a structured classroom simulation.

Evidence from client-based projects and structured PjBL illustrates how these design features can be operationalised. Hulsmeier (2026), for example, shows how client-led curriculum partnerships can support authentic assessment, professional readiness and employability awareness by requiring students to work with real briefs, defined professional roles, weekly tutorials, iterative feedback and public-facing outputs.

In computing and software education, structured workflows are particularly important because professional computing work is often iterative, collaborative and shaped by client and user needs.

Sa'adah et al. (2026) show how Agile practices, including Scrum, Lean Startup and Extreme Programming, can be integrated into a project-based software development curriculum to strengthen industry readiness. This demonstrates the value of iterative structures, defined responsibilities and client and user feedback in connecting classroom projects with professional software practice.

The importance of client involvement and project type is also supported by recent computer science capstone research. Jillepalli et al. (2026a) found that a hybrid instructor–client mentoring model produced higher course performance and career-readiness values than other mentoring arrangements in a two-semester computer science capstone. In a related study, Jillepalli et al. (2026b) found that industry full-stack application projects produced higher course evaluation and self-rated career-readiness scores than other project types. Together, these studies indicate that project type, client involvement, mentoring and the structure of guidance are important design conditions for curriculum-embedded employability learning.

Scenario-based and consultant–client project assessment literature reinforces this point. Parnianifard and Aiyng (2026) show that industry-oriented scenario-based assessment can provide a scalable way to develop and assess soft skills in engineering project-management education. The workflow examined in the present study builds on these approaches but is distinguished by assigning students to consultant-team and peer-client-team roles and embedding staged professional interactions, assessed deliverables and handover processes within normal teaching and assessment.

African and Botswana context for curriculum-embedded employability learning

Curriculum-embedded employability learning is particularly important in African higher education contexts where universities face pressure to align graduates' capabilities with labour-market needs. Yeboah et al. (2026) provide a useful African computing-related example. Their study of database management systems education in Ghana found that students generally perceived their courses as relevant to employment prospects, but also identified limited exposure to modern technologies and called for expanded PjBL, contemporary tools and stronger industry engagement.

In Botswana, the employability challenge is reflected both in policy and in empirical studies. Sebeelo (2026) shows that one major policy representation of Botswana's education problem is the mismatch between tertiary qualifications and labour-market needs. Munjeyi and Schutte (2024) provide more direct evidence from Botswana higher education. Their study found that graduates often fall short in advanced cognitive abilities, socio-behavioural competencies and information technology proficiency. Oshima et al. (2023) similarly identify skills–labour market mismatch, graduate unemployment and employer concerns about practical and soft skills in Botswana's vocational education sector. Together, these studies support the need to examine learning designs that develop work readiness through structured practice.

For computing education in Botswana, the challenge is therefore twofold. Students need technical and disciplinary knowledge, but they also need structured opportunities to practise professional behaviours such as communication, coordination, documentation, problem solving, role responsibility and engagement between consultant teams and peer-client teams. The workflow offers one way of supporting curriculum-embedded employability learning through these practices. However, limited evidence exists on the development of specific dimensions of students' self-reported work readiness during such a workflow, particularly in undergraduate computing education in Botswana.

Summary and research gap

The literature suggests that employability learning may be supported when students engage in structured activities that approximate selected workplace processes. Self-reported work readiness provides a useful way to examine students' preparedness for workplace entry, especially across dimensions such as personal characteristics, organisational acumen, work competence and social intelligence (Caballero et al., 2011). Recent WRS-related literature reinforces the need to treat work

readiness as multidimensional, context-sensitive and empirically measured rather than assumed (Caballero et al., 2026; Lawton et al., 2023; Orr et al., 2023). However, although PjBL, authentic learning and WIL can support employability, less is known about how a structured consultant–client project workflow is associated with students’ self-reported work readiness in undergraduate computing modules, particularly in Global South contexts.

The present study addresses this gap by examining changes in students’ self-reported work readiness before and after participation in the workflow embedded in an undergraduate computing module in Botswana. This focus links the study directly to SoTL and curriculum-embedded employability learning by examining the workflow rather than employment outcomes after graduation.

Methodology

Research design and setting

This study used an exploratory quantitative within-cohort pre–post survey design embedded in normal teaching. Students completed a work readiness survey at the beginning of the module and again at the end of the module. This design was appropriate because the study aimed to examine how students’ self-reported work readiness changed during one semester of participation in the workflow.

The design aligned with the research question because it allowed the same students’ baseline and end-of-module work readiness scores to be compared. The study did not include a separate control group and therefore does not provide definitive causal evidence that the workflow caused the observed changes. Instead, it provides evidence of change over time among students who participated in the module.

A control group was not used because the module was delivered as a single cohort, and the workflow formed part of the normal teaching and assessment design. For ethical and practical reasons, all enrolled students received access to the same learning activities. The design is therefore best understood as a classroom-based pre–post evaluation of within-cohort change rather than an experimental test of causal impact. Accordingly, the study was not designed to isolate the effect of the workflow from maturation, repeated measurement, general semester experience or other contextual influences. Its purpose was to document and interpret within-cohort changes in self-reported work readiness during the module.

Module context and workflow

The study was conducted in an undergraduate elective computing module at a public university in Botswana. The module prepared students to analyse, design, build, test and hand over an e-learning module. It covered topics such as introduction to e-learning, pedagogy of e-learning, learning management systems, massive open online courses (MOOCs), MOOC platforms, online courses, online assessment and emerging technologies in e-learning.

The module was designed to provide preparation relevant to roles such as instructional designers, module developers, information and communication technology coordinators, teaching assistants, educational managers and corporate trainers. The learning outcomes required students to elicit requirements, define scope and audience, apply learning design principles, develop an e-learning module using appropriate tools and demonstrate teamwork and professional client communication across the full project cycle.

The teaching period lasted 14 weeks. Students attended weekly lectures and laboratory sessions. The project was introduced early in the semester, and the WRS pre-module survey was administered during project onboarding. Students were introduced to the workflow through the shared module guide, which outlined the activities, team roles, deliverables and assessment requirements. The workflow was also explained during lectures and reinforced through instructions provided before each

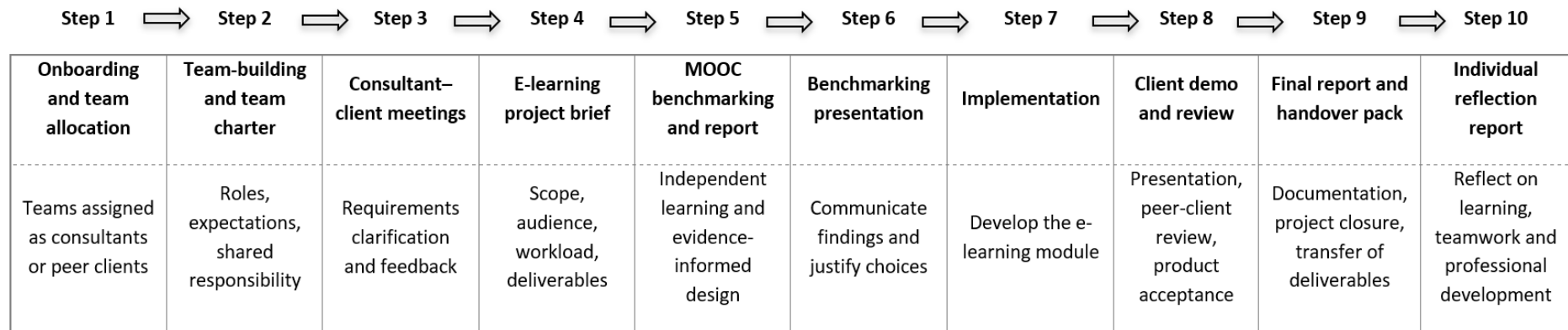
major activity. Students then completed team-building activities, a team charter, consultant–client meetings, project brief development, MOOC benchmarking, implementation, documentation, final reporting and handover activities. The WRS post-module survey was administered at the end of the module after students had completed the main project activities, including implementation, peer-client demonstration and review, final reporting and handover.

Structured consultant–client project workflow

The workflow assigned student teams to act as consultant teams or peer-client teams. Because peer-client teams comprised students rather than external industry or community partners, the workflow represented a structured simulation of workplace processes rather than engagement with a real organisational client. Consultant teams were responsible for gathering requirements, taking MOOCs, preparing individual reports, integrating those reports into a benchmarking report, designing and developing the e-learning module, and preparing final documentation. Peer-client teams were responsible for defining requirements, providing or curating content, reviewing prototypes, running user testing and accepting deliverables.

The workflow included onboarding and team allocation, team building and team charter development, consultant–client meetings, project brief preparation, MOOC benchmarking, benchmarking presentation, implementation, peer-client demonstration and review, and final handover (Figure 1).

Figure 1: Structured consultant–client workflow used in the module



These workflow elements were intended to support students' professional development by making project coordination, communication, documentation and engagement with peer-client teams explicit. The assessment structure reinforced these practices because marks were attached to project-related activities such as the team charter, project brief, MOOC benchmarking, implementation, peer-client demonstration and review, final report and handover pack.

Table 1 shows how the main workflow elements were aligned with employability-oriented functions and WRS dimensions. The mapping was used to clarify the pedagogical logic of the module design. It was not used to score students or to assign individual WRS items to specific graded activities.

Table 1: Alignment between structured workflow elements, employability functions and WRS dimensions

Workflow element	Employability-oriented function	Related WRS dimension
Team charter	Clarified roles, expectations, working arrangements and shared responsibility	Organisational acumen; social intelligence
Consultant–client meetings	Provided practice in professional communication, requirements clarification, engagement with peer-client teams and response to feedback	Social intelligence; organisational acumen
E-learning project brief	Formalised project scope, requirements, audience, workload and deliverables	Work competence; organisational acumen
MOOC benchmarking and report	Supported independent learning, comparison of professional examples and evidence-informed design decisions	Work competence; personal characteristics
Benchmarking presentation	Required consultant teams to communicate findings, justify design choices and respond to the expectations of peer-client teams	Social intelligence; work competence
Implementation	Required application of technical and design skills through the workflow to produce an e-learning module	Work competence
Peer-client demonstration and review	Provided practice in presentation, feedback response, review by peer-client teams and product acceptance	Social intelligence; organisational acumen
Final report and handover pack	Simulated workplace documentation, project closure and transfer of deliverables to a peer-client team	Work competence; organisational acumen
Individual reflection report	Encouraged students to evaluate their learning, contribution, teamwork and professional development	Personal characteristics; social intelligence; work competence

Researcher positionality and reflexivity

The authors were involved in different aspects of both the module and the study. Both authors designed and taught the module and contributed to the design and implementation of the workflow

and associated assessment structure. The first author adapted the WRS for the undergraduate computing context, including decisions about item selection, wording clarification and the change in response format, and administered the survey and collected the data. The second author prepared the quantitative dataset, conducted the statistical analysis and produced the initial interpretation of the results. Two doctoral students, who were independent of the authorship team and are named in the Acknowledgements, reviewed the analysis and assessed whether the interpretations were supported by the quantitative results.

The authors' involvement provided detailed contextual knowledge of the module design, teaching, assessment and implementation. However, their dual roles as educators and researchers also created potential sources of bias. The authors' involvement in designing and assessing the learning activities may have influenced students' survey responses, while their familiarity with the workflow and study aims created a possibility of confirmation bias in interpreting the results. The first author's role in adapting and administering the WRS also meant that decisions about item selection, wording and response format were made by a researcher directly involved in the module.

Several measures were used to strengthen reflexivity and reduce these risks. The adaptation of the WRS and the reasons for item omission and wording changes were documented transparently in Supplementary Table S1. The quantitative analysis followed predefined scoring and data-preparation procedures and reported all WRS dimensions, including non-significant and less robust findings, rather than only statistically significant results. Reliability and sensitivity analyses were conducted, and two doctoral students who were not part of the authorship team independently reviewed the analysis and interpretations. The findings were interpreted cautiously as within-cohort changes in students' self-reported work readiness rather than as causal evidence of demonstrated workplace capability. Alternative explanations for the observed changes, including maturation, repeated measurement, educator influence and the broader semester experience, were also considered.

Participants and ethical considerations

Participants were undergraduate computing students enrolled in the module. The module had 37 enrolled students. Because the study was embedded in a normal module offering, all students participated in the learning activities, but only consenting students' data were included in the research dataset. Participants were fourth-year students aged 21–22 years, and none had formal employment experience. This reflected the local context, in which the university is geographically isolated, employment opportunities near the campus are limited, and students without completed qualifications have little access to formal professional employment. Gender information was not collected because it was not relevant to the study aim or planned analysis.

The analysis reported in this paper uses matched WRS pre- and post-module responses. A total of 34 students completed the WRS pre-module survey and 36 completed the WRS post-module survey. Thirty-four students were initially matched across the WRS pre- and post-module datasets. After excluding two substantially incomplete cases, the final analytic sample comprised 32 students.

The two excluded cases were removed because they had completeness rates of 38.9% and 31.5%, respectively. Because less than 40% of the WRS items were completed in each case, these records were treated as substantially incomplete and were removed before analysis. Two other students had minor item-level missingness but were retained because their WRS completeness rates were high, at 98.1% and 92.6%, respectively.

Student identifiers were used only for matching pre- and post-module records. These identifiers were removed after data preparation and replaced with anonymised participant codes.

Table 2: WRS response flow

Stage	Number of students
Enrolled in the module	37
Completed WRS pre-module survey	34
Completed WRS post-module survey	36
Matched across pre- and post-module surveys	34
Excluded for substantial incompleteness	2
Final analytic sample	32

Ethical approval was granted by the Human Ethics Research Committee of Botswana International University of Science and Technology under certificate reference HREC-031/7/11/2025. The surveys were embedded in normal teaching activities, but research use of the data required consent. Participation in the research component was voluntary. Students were informed that their decision to participate or not participate in the research component would not affect their grades, access to learning activities or relationship with the teaching team.

Student records were de-identified before analysis, and findings are reported in aggregate form. Identifying information used for matching was removed after data preparation, and the analytic dataset used anonymised participant codes.

Materials

Work readiness was measured using an adapted WRS based on Caballero et al. (2011). The original WRS was developed to assess graduate work readiness as a multidimensional construct and includes four factors: personal characteristics, organisational acumen, work competence and social intelligence.

The version used in this study contained 54 items and adopted a five-point Likert-type response scale to provide a familiar and manageable format for undergraduate respondents. Response options ranged from 1 to 5, with higher values indicating stronger agreement after reverse-coding where required. The instrument measured four dimensions of work readiness: personal characteristics, organisational acumen, work competence and social intelligence. Overall WRS was calculated as the mean of all WRS items. The WRS captures respondents' self-reported work readiness, understood as perceived preparedness for workplace entry (Caballero et al., 2011; Orr et al., 2023). As a self-report questionnaire, it does not provide behavioural, performance-based or externally assessed evidence of actual workplace capability.

The WRS was selected because it measures self-reported work readiness as a multidimensional construct rather than as a single general employability perception, consistent with the study's focus on its four dimensions.

The instrument was shortened and contextually adapted because the original WRS was developed with recently employed graduates and graduate job applicants, many of whom had some workplace experience, whereas the respondents in the present study were undergraduate students with no employment experience. The adapted version retained 19 of the original 22 personal characteristics items, 15 of 19 organisational acumen items, 14 of 15 work competence items and 6 of 8 social intelligence items. Items were removed where they required workplace or organisational experience that students were unlikely to possess, appeared to repeat concepts already represented by retained items, or contained wording that students might find difficult to understand or answer meaningfully. Before administration, a small number of undergraduate students reviewed the questionnaire to determine whether the items were understandable and answerable in their context. Selected wording

was clarified by referring to familiar university and project situations while retaining the intended work-readiness concept. Supplementary Table S1 (Appendix 1) maps the 54 administered items to the original WRS, identifies the ten omitted items and their subscales, provides the reason for each omission, and documents wording changes made to retained items.

Because the WRS was adapted in item number, wording and response format, it should be understood as a context-specific version of the WRS rather than as a full replication of the original 64-item scale. The study does not claim that the original WRS factor structure or measurement equivalence was preserved. The sample size was insufficient for robust examination of the 54-item instrument's factor structure. Internal consistency was therefore assessed for each adapted subscale and the overall scale before the pre–post results were interpreted.

Data collection

The WRS survey was administered twice during the module. The pre-module survey was administered in Week 1 during project onboarding, before students had completed the workflow activities. The post-module survey was administered at the end of the module after students had completed the main project activities, including implementation, peer-client demonstration and review, final reporting and handover.

Survey administration was integrated into the module schedule. However, research use of the survey data required consent. Only responses from students who consented to the research use of their data were included in the dataset.

Data analysis

Data preparation and scoring

The data were prepared in several stages. First, the pre- and post-module datasets were ordered by item text to ensure that WRS items appeared in the same sequence in both datasets. Second, duplicate and incomplete submissions were checked. Where a student had more than one submission, the most complete valid submission was retained. Third, student records were matched across the pre- and post-module files. Fourth, negatively worded items were reverse-coded using the formula 6 minus the original response value. Fifth, subscale and overall WRS scores were calculated for each student.

Missing responses were treated as missing and were not coded as low scores. Two matched cases were excluded before analysis because they were substantially incomplete, with WRS completeness rates of 38.9% and 31.5%. Two retained students had minor item-level missingness, with WRS completeness rates of 98.1% and 92.6%. For retained cases with minor missingness, subscale and overall means were calculated from the available valid responses. All remaining students had a completeness rate of 100%. The final analysis was based on 32 students with usable matched WRS data.

Statistical analysis

Descriptive statistics were calculated for each WRS subscale and for overall WRS. These statistics included pre- and post-module means, mean change and standard deviation of change scores. Change scores were calculated by subtracting the pre-module score from the post-module score for each participant. Positive values therefore indicated an increase in self-reported work readiness.

Internal consistency reliability was assessed for the WRS subscales and the overall WRS at pre- and post-module surveys. Cronbach's alpha was used because each WRS dimension was analysed as a multi-item scale (Cronbach, 1951; Tavakol & Dennick, 2011). Reliability values are reported in the Results section because they are empirical findings from the present dataset. Reliability estimates were interpreted cautiously because the matched sample was modest and because the study used an adapted 54-item version of the original WRS.

The distributions of the pre–post difference scores were examined using histograms, Q–Q plots and Shapiro–Wilk tests (Ghasemi & Zahediasl, 2012; Shapiro & Wilk, 1965). The full normality-assessment results, including Supplementary Table S2 and the corresponding histograms and Q–Q plots, are available in Supplementary Material S2 (Appendix 2). The tests indicated departures from normality: $W = .933$, $p = .049$ for personal characteristics, $W = .735$, $p < .001$ for organisational acumen, $W = .876$, $p = .002$ for work competence, $W = .902$, $p = .007$ for social intelligence, and $W = .877$, $p = .002$ for overall WRS. Given these departures from normality and the modest sample size, Wilcoxon signed-rank tests were used instead of paired-samples t-tests to compare pre- and post-module scores (Wilcoxon, 1945). The Wilcoxon signed-rank test is appropriate for paired non-parametric comparisons where the same participants provide two related observations and the analysis does not assume normally distributed difference scores (Wilcoxon, 1945). Effect size was calculated as:

$$r = \frac{|Z|}{\sqrt{N}}$$

where Z is the standardised Wilcoxon test statistic and N is the number of paired observations included in the test (Rosenthal, 1991).

The absolute value of r was reported so that larger values indicated stronger effects regardless of direction. For the main analysis, $N = 32$. Statistical significance was assessed using two-tailed p -values, with $p < .05$ used as the conventional threshold for statistical significance. However, p -values were interpreted alongside descriptive changes, effect sizes and sensitivity analysis, rather than as the sole basis for interpretation (Wasserstein & Lazar, 2016). Effect sizes were interpreted using conventional benchmarks of approximately .10 for small, .30 for medium and .50 for large effects, while recognising that such thresholds are only general guidelines and should be interpreted in relation to the study context (Cohen, 1988; Rosenthal, 1991).

A sensitivity analysis was conducted excluding one participant, S27, who showed an unusually large increase in WRS scores. The participant was retained in the main analysis because the case was correctly matched and no coding error was identified. The sensitivity analysis was used to assess whether the main findings were dependent on this influential case.

The second author conducted the statistical analysis and developed the initial interpretation of the findings, which was subsequently reviewed by both authors and by two doctoral students outside the authorship team to assess whether the interpretations were supported by the quantitative results.

Rigour and validity

Several steps were taken to strengthen rigour and validity. First, the design was aligned with the study aim and research question by comparing matched pre- and post-module responses from the same students. This reduced between-person variation and allowed within-student change to be examined.

Second, data preparation procedures were documented and applied consistently. Pre- and post-module survey items were aligned by item text, duplicate submissions were checked, substantially incomplete cases were excluded using explicit completeness criteria, and minor missingness was handled by calculating mean scores from available valid responses.

Third, the adapted WRS was treated cautiously. Because the study used a 54-item version of the original WRS and a five-point Likert-type response scale, reliability was assessed for the present sample before interpreting subscale results. Subscale-level reliability estimates are reported in the Results section.

Fourth, the analysis did not rely only on statistical significance. Descriptive changes, effect sizes and sensitivity analysis were used to support interpretation.

Fifth, claims were limited to self-reported work readiness. The findings were therefore interpreted as changes in students' self-reported work readiness rather than as evidence of demonstrated workplace

performance or later employment outcomes. This limitation is consistent with the study purpose, which was to examine self-reported work readiness as a short-term educational outcome of a curriculum-embedded employability-learning design.

Results

This section presents findings in relation to the research question: How did students' self-reported work readiness change after participation in the workflow embedded in an undergraduate computing module? Results are presented in four parts: (1) reliability of the adapted WRS, (2) descriptive pre–post changes, (3) Wilcoxon signed-rank test results, and (4) sensitivity analysis excluding one influential case.

Reliability of the adapted WRS

Internal consistency reliability was calculated for the adapted 54-item WRS at pre- and post-module surveys before interpreting pre–post changes. Table 3 reports Cronbach's alpha values for each WRS subscale and for the overall WRS.

Table 3: Internal consistency reliability of WRS subscales

WRS subscale	Pre-test reliability	Post-test reliability
Personal characteristics	$\alpha = .75$	$\alpha = .86$
Organisational acumen	$\alpha = .93$	$\alpha = .75$
Work competence	$\alpha = .88$	$\alpha = .76$
Social intelligence	$\alpha = .71$	$\alpha = .53$
Overall WRS	$\alpha = .91$	$\alpha = .82$

Reliability was acceptable to high for most subscales and for the overall WRS. The post-test reliability for social intelligence was below conventional thresholds; therefore, findings for this subscale are reported but interpreted cautiously.

Descriptive pre–post changes in work readiness

Table 4 presents descriptive statistics for each WRS subscale and for overall WRS. Mean change was calculated by subtracting the pre-module score from the post-module score. Positive values indicate higher self-reported work readiness at the post-module survey.

Table 4: Descriptive Pre–Post Changes in Work Readiness

WRS subscale	Pre-test mean	Post-test mean	Mean change	SD of change
Personal characteristics	3.24	3.21	-0.03	0.66
Organisational acumen	4.20	4.43	0.23	0.71
Work competence	3.76	4.11	0.35	0.60
Social intelligence	3.71	3.96	0.25	0.58
Overall WRS	3.70	3.88	0.17	0.42

Note. SD = standard deviation

The descriptive results show increases in organisational acumen, work competence, social intelligence and overall WRS. The largest mean increase was observed for work competence, followed by social intelligence, organisational acumen and overall WRS. Personal characteristics showed a small decrease.

Wilcoxon signed-rank test results

Wilcoxon signed-rank tests were conducted to examine whether the observed pre–post changes were statistically significant. Table 5 presents the results for the five paired comparisons.

Table 5: Wilcoxon signed-rank test results for WRS pre–post comparisons

WRS subscale	Wilcoxon W	p-value	Effect size <i>r</i>	Result
Personal characteristics	249.00	.779	.05	Not significant
Organisational acumen	124.00	.043	.36	Significant
Work competence	95.50	.002	.56	Significant
Social intelligence	110.50	.020	.41	Significant
Overall WRS	135.00	.027	.39	Significant

The Wilcoxon signed-rank tests showed statistically significant increases in organisational acumen, work competence, social intelligence and overall WRS. Personal characteristics did not change significantly.

The largest effect size was observed for work competence ($r = .56$), followed by social intelligence ($r = .41$), overall WRS ($r = .39$) and organisational acumen ($r = .36$). The effect size for personal characteristics was very small ($r = .05$). Because post-test reliability for social intelligence was low, this statistically significant result should be treated cautiously.

In relation to the research question, the main analysis shows that students' self-reported work readiness increased significantly in three WRS subscales and in overall WRS after participation in the workflow. No statistically significant change was found for personal characteristics.

Sensitivity analysis excluding S27

One participant, S27, showed an unusually large increase in WRS scores, especially in organisational acumen, work competence, social intelligence and overall WRS. The case was retained in the main analysis because it was correctly matched and no coding error was identified. However, a sensitivity analysis was conducted excluding S27 to examine whether the findings were dependent on this case (Table 6).

Table 6: Sensitivity analysis excluding S27

WRS subscale	Pre-test mean	Post-test mean	Mean change	SD of change	Wilcoxon W	p-value	Effect size <i>r</i>	Result
Personal characteristics	3.24	3.22	-0.02	0.67	227.00	.680	.07	Not significant
Organisational acumen	4.30	4.43	0.13	0.41	124.00	.072	.32	Non-significant positive trend
Work competence	3.82	4.10	0.28	0.44	95.50	.003	.54	Significant
Social intelligence	3.77	3.96	0.19	0.45	110.50	.034	.38	Significant
Overall WRS	3.75	3.87	0.12	0.31	135.00	.045	.36	Significant

Note. SD = standard deviation

The sensitivity analysis showed that work competence, social intelligence and overall WRS remained statistically significant after excluding S27. Personal characteristics remained non-significant. Organisational acumen remained positive in direction but was reduced to a non-significant result, $p = .072$.

Together, the main and sensitivity analyses show that the most robust pre–post increases were observed for work competence and overall WRS. Social intelligence also remained statistically significant in both analyses, although this result should be interpreted cautiously because of the low post-test reliability for this subscale. Organisational acumen increased significantly in the main analysis but was more sensitive to the inclusion of S27. Personal characteristics did not change significantly in either analysis.

Discussion

Overview of findings

The pattern of findings is consistent with the design logic of the module. The most robust increases were in work competence and overall WRS, with social intelligence also significant but requiring caution because of low post-test reliability. Organisational acumen improved in the full sample but was sensitive to one influential case, while personal characteristics did not change significantly. These differences suggest that the pattern of change was more closely aligned with practised workplace behaviours than with broader personal attributes.

The findings should not be interpreted as evidence that the module caused the observed changes. The study used a within-cohort pre–post design without a control group. Several alternative explanations for the observed pre–post changes remain possible. These include normal maturation during the semester, increased confidence, familiarity with the survey instrument, end-of-semester optimism, educator influence and the general experience of completing a substantial project. The design cannot separate these influences from changes associated with participation in the workflow. At the same time, the pattern was not uniform across WRS dimensions: the strongest changes occurred in work competence and overall self-reported work readiness, while personal characteristics did not change significantly. This differentiated pattern supports cautious pedagogical interpretation but not causal attribution. This interpretation is consistent with Caballero et al.'s (2026) distinction between work readiness and broader graduate employability: the study measured students' self-reported work readiness during the workflow, not later employment outcomes. Accordingly, higher post-module WRS scores should be interpreted as changes in students' self-reported work readiness rather than as evidence of demonstrated workplace performance.

The workflow and work competence

The largest and most robust increase was observed in work competence. This pattern is consistent with the possibility that the module supported students' confidence in performing work-related tasks and with literature suggesting that employability learning may be strengthened when students are guided through professional processes rather than merely assigned a project. In many group assignments, students are expected to organise themselves informally. In this module, professional practices were built into the structure of the work through project briefs, benchmarking, implementation, demonstration, reporting and handover.

The finding is consistent with authentic learning theory, which argues that learning is strengthened when students engage in complex tasks that resemble real-world practice and require the production of meaningful outputs (Herrington & Oliver, 2000). It also aligns with project- and problem-based learning literature, which suggests that extended projects can support applied competence when students engage with complex and meaningful tasks (Hmelo-Silver, 2004; Thomas, 2000). More recent computing and software education research similarly shows that structured project processes,

including Agile-oriented workflows, client involvement and project type, can shape students' self-rated career and professional readiness (Jillepalli et al., 2026a, 2026b; Sa'adah et al., 2026).

Work competence was the WRS dimension most directly aligned with the module's deliverables, including the e-learning project brief, benchmarking report, developed module, peer-client demonstration and review, and handover pack. This alignment helps explain why work competence showed the strongest and most robust improvement.

The workflow and social intelligence

Social intelligence also increased significantly in both the main and sensitivity analyses. This result is important because computing education often emphasises technical competence, while workplace success also depends on interpersonal capability. Students in this module had to communicate within teams, interact across consultant-team and peer-client-team roles, clarify requirements, respond to feedback and coordinate work between the two types of teams. The workflow also required them to negotiate requirements, explain decisions, respond to feedback and coordinate across their assigned roles.

This finding aligns with collaboration-script theory, which suggests that structured roles and interaction routines can support more productive collaboration (Kollar et al., 2006; Weinberger et al., 2009). From a SoTL perspective, this is important because it shows how interpersonal and professional communication can be deliberately embedded into computing coursework rather than treated as an incidental outcome of group work.

At the same time, the social intelligence finding should be interpreted cautiously because the post-test reliability for this subscale was low ($\alpha = .53$). Although six of the original eight social intelligence items were retained, the lower reliability may reflect the modest sample size, restricted response variation, the omission of two original items, or differences in how computing students interpreted the adapted items. This does not invalidate the observed pre-post change, but it means the result should be treated as promising and requiring confirmation in a larger sample.

Organisational acumen and workplace understanding

Organisational acumen increased significantly in the main analysis, although the result became a non-significant positive trend after excluding S27. This suggests that the module may have supported students' understanding of organisational processes, but this finding should be interpreted cautiously.

Organisational acumen is especially relevant to the workflow. Students had to work with requirements, scope, expectations of peer-client teams, deliverables, approvals, documentation and acceptance processes. These activities required students to engage with how work is coordinated, reviewed and accepted in professional settings.

The sensitivity analysis indicates that the organisational acumen result was partly influenced by one participant with an unusually large increase. The direction of change remained positive, but the evidence was weaker than for work competence and overall WRS.

This finding has a useful pedagogical implication. Future iterations of the module could strengthen organisational acumen by making organisational processes more explicit. Examples include clearer peer-client approval protocols, formal change-request procedures, role-based accountability logs, structured meeting records and guided reflection on how project decisions are shaped by peer-client expectations, constraints and acceptance criteria.

Stability of personal characteristics

Personal characteristics did not change significantly. This result is theoretically plausible. Personal characteristics such as adaptability, resilience, self-confidence, responsibility and willingness to learn

may be relatively stable and less likely to change substantially over one semester. They may require longer-term developmental experiences, repeated exposure across multiple modules, mentoring or WIL placements.

The absence of change in personal characteristics should therefore not be interpreted as a failure of the module. Instead, it suggests that the workflow may be most strongly associated with changes in dimensions that are directly practised through it, such as competence, social interaction and organisational understanding. This finding supports the value of reporting WRS subscales separately, because different dimensions may respond differently to a single semester of curriculum-embedded employability learning.

Contribution to SoTL and curriculum-embedded employability learning

The study contributes to SoTL and curriculum-embedded employability learning by showing how the workflow can make professional practices visible, structured and assessable within undergraduate computing education. Rather than treating employability as a general aspiration or relying only on employment outcomes measured after graduation, the study uses self-reported work readiness as a proximal, multidimensional educational outcome that can be assessed before and after a curriculum-embedded employability-learning experience. This provides educators with evidence of changes in students' self-reported work readiness during the workflow, while post-graduation employment outcomes are more distal and influenced by labour-market conditions and other factors beyond the workflow.

The authenticity of the workflow was procedural rather than organisational. Students enacted consultant-team and peer-client-team roles and followed workplace-like processes, but the peer-client teams comprised students rather than representatives of external organisations. The simulation therefore did not reproduce the operational stakes, commercial consequences, power relationships or accountability associated with a real industry or community client.

The study also contributes to discussions of employability in Global South higher education contexts. Graduate employability and work readiness are often discussed in relation to labour-market needs, but fewer studies examine how self-reported work readiness changes during specific classroom designs in undergraduate computing education. This study provides one example of how work readiness development can be embedded into normal teaching and assessment through structured project activities.

The study makes a contribution to methodology, by reporting subscale-level WRS results, reliability estimates, missing-data decisions and sensitivity analysis. This is important because overall work-readiness gains can mask differences across dimensions (Caballero et al., 2026; Lawton et al., 2023; Orr et al., 2023). These exploratory findings indicate that the most pronounced pre–post changes occurred in applied work competence, while social intelligence and organisational acumen require more cautious interpretation.

Limitations

This study has several limitations. First, the study used a single-cohort pre–post design without a control group, comparison condition, randomisation or alternative intervention. The findings therefore show within-cohort change but cannot establish that the workflow caused the observed differences. Alternative explanations include maturation, increased confidence, repeated exposure to the survey, end-of-semester optimism, educator influence and the broader experience of completing a substantial project. In addition, because both authors designed, taught and assessed the module, and the first author administered the survey, the educator–researcher relationship may have influenced students' responses. The authors' familiarity with the workflow may also have influenced

interpretation despite the documented analytical procedures and review by two doctoral students outside the authorship team. These potential influences cannot be eliminated fully.

Second, the study used a 54-item context-specific adaptation of the original 64-item WRS and changed the original response format to a five-point scale. The omitted items, retained-item counts, reasons for removal and wording adaptations are documented in Supplementary Table S1. Although all four WRS dimensions remained represented and internal consistency was assessed, the modest sample did not permit examination of the adapted instrument's factor structure or measurement equivalence with the original scale. Construct validity of the adapted version therefore cannot be assumed, and direct comparisons with studies using the original WRS should be made cautiously. The sample of 32 matched respondents also limits the stability of reliability estimates and subscale-level comparisons. Future research should evaluate the adapted instrument through cognitive interviewing and psychometric testing with a substantially larger sample.

Third, the study measured self-reported work readiness rather than demonstrated workplace capability. It did not include behavioural assessments, independent evaluators, employer or external-client evaluations, rubric-based observations, objective performance measures or longitudinal employment outcomes. The findings therefore concern students' self-reported work readiness and should not be interpreted as evidence of actual workplace performance or later employment success. Future studies should triangulate self-reported work readiness with independent performance-based assessments, external-client or employer feedback, and longitudinal graduate outcomes.

Fourth, the workflow involved student peer-client teams rather than external industry or community partners. Accordingly, the workflow provided procedural authenticity but not the organisational authenticity, external accountability or real-world consequences associated with an external client. The study was also conducted in one module at one institution, limiting statistical generalisability to other computing students and higher education contexts. Future studies should compare peer-client simulations with projects involving industry or community partners across multiple modules and institutions.

Conclusion

This exploratory classroom-based evaluation examined changes in students' self-reported work readiness during the structured consultant–client project workflow embedded in an undergraduate computing module in Botswana.

The most robust increases were observed in work competence and overall self-reported work readiness. Social intelligence also increased, although this finding should be interpreted cautiously because of its low post-test reliability. Organisational acumen improved in the full-sample analysis but was less robust in the sensitivity analysis, while personal characteristics did not change significantly.

The study contributes to SoTL and curriculum-embedded employability learning by specifying an assessable workflow through which professional roles, staged interactions and workplace-like project practices can be embedded in normal computing teaching. It also demonstrates the value of examining self-reported work readiness as a multidimensional and proximal educational outcome.

The study should not be interpreted as causal evidence because it used a single-cohort pre–post design without a control or comparison condition. Its single-module, single-institution design also limits statistical generalisability. However, the workflow may be transferable to comparable project-based computing contexts because its roles, stages and assessment processes can be adapted to different modules and settings. Further research should examine this transferability across institutions, disciplines and external-client contexts using larger samples, comparison designs and performance-based measures.

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Conflict of interest

The authors declare that they have no conflict of interest.

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Data availability

The anonymised analytic workbooks supporting the analysis reported in this article are available in Figshare at <https://doi.org/10.6084/m9.figshare.32306844>. The workbooks include the processed pre- and post-module WRS data and analysis outputs used to generate the reported results.

Statement on the use of Artificial Intelligence

A generative artificial intelligence tool (OpenAI's ChatGPT-5.5) was used to support language refinement, editing and manuscript preparation. The authors reviewed, verified and revised all AI-assisted outputs and take full responsibility for the content, analysis, interpretation and final version of the manuscript.

Contributions against CReDIT

Irina Zlotnikova: Conceptualisation, methodology, investigation, data curation, formal analysis, writing – original draft, writing – review and editing.

Thabiso Maupong: Methodology, investigation, validation, writing – review and editing, project administration.

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Appendix 1

Supplementary Table S1 is available in Figshare: <https://figshare.com/ndownloader/files/66706241>

Appendix 2

Supplementary Material S2 is available in Figshare:

<https://figshare.com/ndownloader/files/66766088>