A Practical Approach to Assessing IT Professional Skills

DAVID S. BOWERS, The Open University, UK
MIHAELA SABIN, University of New Hampshire, USA
RAJENDRA K. RAJ, Rochester Institute of Technology, USA

The release of the Information Technology (IT) 2017 curricular guidelines provided the impetus to focus on students' professional competencies by incorporating authentic practice into disciplinary content. Authentic practices require appropriate learning experiences such as workplace-bound experiences, employer engagement with programs via paid internships, and critical reflection on what was learned. Both professional technical and non-technical skills must be emphasized for such authenticity. However, practical assessment of the learning of professional competencies remains challenging. This paper develops such a practical assessment approach to IT competencies. It builds on the industry-led Skills Framework for the Information Age (SFIA) that defines over 120 IT professional skills across seven levels of responsibility and experience. SFIA provides actionable and measurable activities and behaviors, which IT graduates need to demonstrate in the workplace. The paper explores the assessment of student performance on authentic, real-world tasks using a rubric-based scoring scheme supported by a systematic collection of sample student work over their time in the program. It concludes with a discussion of the validation of the proposed approach to demonstrate its practicality.

CCS Concepts: • **Social and professional topics → Computing education**;

Additional Key Words and Phrases: IT competencies, dispositions, skills frameworks, SFIA skills framework, CC2020

ACM Reference Format:
David S. Bowers, Mihaela Sabin, and Rajendra K. Raj. 2023. A Practical Approach to Assessing IT Professional Skills. In *The 23rd Annual Conference on Information Technology Education (SIGITE '23), October 11–14, 2023, Marietta, GA, USA*. ACM, New York, NY, USA, 10 pages. https://doi.org/10.1145/3585059.3611426

1 INTRODUCTION

The Information Technology 2017 curricular guidelines (IT2017) emphasize the development of Information Technology (IT) *professional competencies* by integrating disciplinary content with authentic practices [21]. Competency assessments must consider aspects of work by which professionals demonstrate their expertise. To link competency-based IT learning experiences to a professional context, academic programs need to consider:

> "workplace-bound experiences, [...] active involvement with employers to support internships and co-op programs [...], authentic problems and engagement of diverse teams, [...] project-based activities by using professional tools, [and] deliberate and critical reflection on practice [...]" [21, p. 31].

The IT2017 report [21, chapter 5] outlines professional technical and non-technical skills valued by employers almost ten years ago and projected to be in high demand through 2024.

The industry-led Skills Framework in the Information Age (SFIA) provides actionable and measurable activities and behaviors that IT graduates need to demonstrate in the workplace [26]. It offers descriptive statements of the full range of professional skills in the IT sector across seven levels of responsibility and experience. SFIA Level 3, for instance, captures the skills and responsibility characteristics that correspond to the IT graduate skill set. Authentic and performance-based assessment is socially-situated and formative of student agency [13, 15, 27]. This means that the assessment incorporates tasks that practitioners perform in a professional setting. SFIA Level 3 professional competency statements inform the selection of performance-based assessment tasks aimed at practicing and developing IT technical skills over a period of time.

For authentic assessments, educators use a list of criteria specific to the performative tasks students engage in. To feature and evidence purposeful and integrated work over time, students use portfolios to collect and document their progress and achievement [12]. The evaluation of student performance on authentic, real-world tasks is guided by (1) clearly-defined criteria or a rubric-based scoring method and (2) portfolio-based, systematic collection of representative samples of student work over time [15, 27, 28].

This paper describes an assessment approach and tool for evaluating students' IT technical competence through work-based experiences. Section 2 examines the literature in competency, setting the stage for assessing IT professional skills in Section 3. Testing the assessment approach is covered in Section 4 while Section 5 discusses the practicality of the proposed approach to assessing IT professional competencies. Section 6 briefly discusses the contributions of this work and future directions.

2 RELATED WORK

In everyday language, the word "competency" is used interchangeably with "capability", "expertise", "proficiency", "capacity", or "ability" to carry out work-related tasks or goal-oriented activities. Competency literature shows the lack of one single widely-accepted objective definition of competency, despite its extensive use in education and work [24, p. 346]. Common to several definitions of competency is that they cluster *knowledge*, *skills*, and *personal characteristics* in the context of performance on a job or meeting the responsibilities of a job role. The association between competency and performance means that competency predicts behavior and allows for measuring a competency against a specific criterion or standard [10, 23].

In the field of human resources development, David McClelland began the competence movement in 1973p, arguing that competence assessment is a better predictor of successful performance than IQ and personality tests [14]. Educational institutions' response to the competence movement in business organizations was the adoption of competency-based approaches to curriculum design and accreditation standards of educational programs. In the 1970s, nursing, legal, and teacher vocational training programs in the US began to study the development of desired skill sets by examining behaviors of outstanding professionals in the field [9].

Increased attention to competency-framed curricula since then stems from the academic programs' ongoing efforts to bridge the persisting gap between the graduates' adequate preparation for entry-level positions and the competencies employers expect of these new hires. The survey of employers on higher education conducted by the Association of American Colleges and Universities (AACU) in 2020 shows that less than half of the employers are *very satisfied* with graduates' preparation for the workplace. Highly valued learning practices that employers highlight in the survey are internships and apprenticeship experiences. Another educational strategy that resonated with employers' needs is the use of portfolios that help students communicate the skills they develop during their time in college.

The National Research Council's report "Education for Life and Work" [18] draws attention to a holistic view of competency, which integrates the cognitive competency domain (inclusive of knowledge and skills) with two additional domains of *intrapersonal* competencies ("capacity to manage one's behavior" and "emotions to achieve one's goals") and *interpersonal* competencies ("expressing ideas" and "interpreting and responding to messages from others"). To achieve competencies spanning these interrelated domains requires that content knowledge acquisition and skill development be facilitated through "acts of doing and carrying out performative tasks" [20]. Several competency learning models underscore the importance of learning by doing and the authentic, performance-based assessment of competency development.

In education, competency models that go beyond the cognitive domain integrate practice progressions and measurement of execution techniques (see Simpson's psychomotor model [22]) and scaffold performance from the application of knowledge to a demonstration of skill and independent performance in clinical practice (Miller's clinical assessment model [16]). Fink's model of significant learning directly addresses the limitation of Bloom's famous hierarchical model of cognitive learning outcomes by exposing affective, emotional, social, and motivational aspects of learning, such as caring, learning about oneself and others, and learning to learn [6]. Instead of hierarchically organizing cognitive competencies, an integrative model of competency combines cognitive competencies with performative or skill-oriented competencies and the human side of professional development [20]. The IT2017 [21] and CC2020 [5] curricular reports promote this integrative model by distinguishing between three competency components: content knowledge, skill development, and dispositions. Where the curricular reports fall short is specifying competencies with direct applicability in the workplace, operationalized by real-world, authentic tasks recent graduates could be expected to perform.

This paper contextualizes the concept of competency by practice-based learning in the profession. Professional competencies and practice-based learning "are intrinsically related to one another," and this interdependence impacts directly learner assessment [17]. Our operational definition of competency takes into account "displayed behavior within a specialized domain in the form of *consistently demonstrated actions* of an individual that are both minimally *efficient in their execution* and *effective in their results*" [10]. A similar emphasis on "*repeated, successful application of knowledge and skills to complete tasks, in a professional manner and reproducibly over a period of time*" is in the competency definition for ISO certification of systems and software engineering professionals [11].

As mentioned previously, the SFIA Skills Framework (version 8) [26] describes professional skills and competencies required broadly across computing, including information technologies. SFIA has users in over 180 countries ranging from small employers, professional bodies, and multi-national corporations to public sector enterprises. SFIA describes 121 technical skills and defines seven levels of responsibility under which these skills are deployed based on individual experience and enterprise needs. Each level of responsibility, spanning from *follow* to *set strategy/inspire/mobilise*, is characterized by category descriptors: autonomy, influence, complexise , knowledge, and business skills. Several of these characteristics correspond to dispositions articulated in CC2020 [4]. SFIA is maintained in an open, collaborative process by its global community over a three-year cycle. It is free for most individual and non-commercial applications while a small annual license fee for commercial use helps to support updates and materials. This study uses SFIA Level 3 to design the scoring tool criteria and student digital portfolios to collect assessment data.

3 IT PROFESSIONAL SKILLS ASSESSMENT

We describe our criterion-based assessment approach for competency, based on mapping the content of a student portfolio to a professional skills framework. Expert review of the assessment requirements, design, and implementation, as well as of the delivered outcomes was undertaken by a panel comprising academic, industrial, and professional members, including the SFIA consultant leading assessment activities for the SFIA Foundation [2].

3.1 The Portfolio of Evidence

Evidence is accumulated in a student's portfolio: the format can be flexible, as long as it is possible to reference individual portfolio entries, e.g., by date, so that the assessment can be audited. The portfolio should include (near) contemporaneous notes of the student's completion of tasks, as well as in-context reflection, including any insights gained, by the student as a developing professional.

Given that competency is evidenced by the repeated *completion* of tasks in the real world, rather than by merely participating in or attempting them, completion should be the focus of the majority of the entries: what has the student *done*? What were the outcomes? Successes, challenges, and not achieving projected outcomes are noted in the task completion description. Furthermore, to allow for the required repetition, the portfolio should cover an extended period - such as a semester or even a complete year - of real-world experience – rather than a trivial period such as a single "taster" week of "work experience."

It may be challenging to include detail in a portfolio, e.g., a student re-imaging remotely managed computing devices would be unwise to include a separate build-log for each device. Nevertheless, some idea of volume – how many devices, over what period, problems encountered, and challenges faced – all help to transform a narrative into evidence. There may also be issues around commercial sensitivity, so students may need support to anonymize the entries to maintain confidentiality. Finally, it is essential that the evidence is *verified*, by the student's workplace supervisor or a senior colleague, to confirm that the stated achievements are genuine.

3.2 The Assessment Process

We describe the assessment of IT professional competencies in a single SFIA skill at SFIA Level 3. SFIA Level 3 is appropriate for students undertaking work experience towards the end of a baccalaureate degree, with Level 2 appropriate for earlier stages. We note that competency does not represent only technical skills. SFIA also defines responsibility characteristics, which correspond to dispositional competencies included in the CC2020 report [5].

The first step is to identify **one** SFIA skill against which to map the portfolio's entries. The 121 SFIA skills represent the whole spectrum of skills in the IT and computing professions, ranging from high-performance computing and data science, through information- and security-strategy, to service- and project-management. Not all skills are appropriate for every level of responsibility, so only 81 are defined at SFIA level 3. The SFIA summary chart [25] lists all the skills grouped into six categories, each with several subcategories, and shows the levels at which each skill is defined. For example, the skill *User experience analysis*, used as an example in Section 3.4, is one of four skills in *User experience*, which is a sub-category of *Development and Implementation*. Figure 1 shows that *User experience analysis* is defined for SFIA levels 3, 4, and 5, while the other three skills in the sub-category are defined up to SFIA level 6, and one is defined for SFIA level 2. The four-letter codes shown against each skill are used in some applications developed to support SFIA.

Selecting the skill requires assessors, such as internship supervisors, to be sufficiently aware of the profession to identify, from a cursory scan of the portfolio, the most appropriate skill defined at SFIA Level 3. Each descriptions includes between 2 and 5 sentences which are the *components* of the skill. Multiple portfolio entries need to contain evidence of the *successful application* of each skill component through *task completion*, together with appropriate *reflection*. The assessment score measures how well the portfolio demonstrates competency in the chosen SFIA skill.

The assessment is criterion-based: the only judgment needed is whether or not a portfolio entry demonstrates application of one (or more) components of a skill. The scoring scheme is a development of a scoring scheme deployed

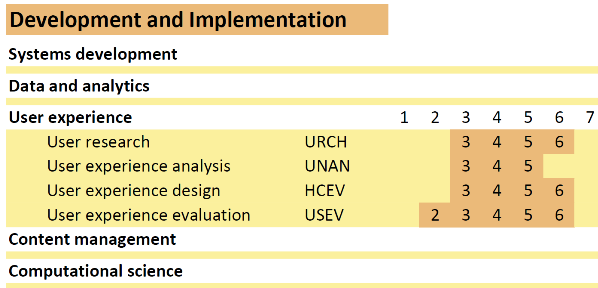

Fig. 1. Extract from Summary Chart of SFIA skills

previously by one of the authors for a university work-based learning module. The scoring scheme was found scalable and auditable, and to lead to an appropriate distribution of grades.

3.3 Scoring

The portfolio entries are assessed for two aspects: *technical achievement* and *reflection*. For each aspect, specific *items of evidence* are required, and those items of evidence are measured against a set of *quality criteria*. The items of evidence and the quality criteria specified for "Technical Achievement" and for "Reflection" are shown in Table 1. The same scoring scheme, set out in Table 2, is applied for each of the aspects.

Table 1. Assessment criteria for portfolio entries

(a) **Technical Achievement Evidence**	**Weight:16**
Item of evidence	*Quality criteria*
• Portfolio entries showing completion of components from a SFIA skill in a real-world environment • Supervisor comments confirming the accuracy of the portfolio entries	• There is more than one portfolio entry for at least 85% of the components • There is more than one portfolio entry for at least 50% of the components • Supervisor comments evaluate achievements against their context • Portfolio entries present evidence rather than assertion
(b) **Reflection Evidence** *may be in a separate document*	**Weight: 9**
Item of evidence	*Quality criteria*
• Reflective ad-hoc portfolio entries for achievements across skill • Portfolio identifies area(s) of personal development • Portfolio identifies instances of personal/professional accountability for achievements	• The style of portfolio entries is appropriately professional • Reflection is based on evidence rather than assertion • Personal development claims supported by comparison of achievements across the period of experience • Recognition of accountability related to customer-facing achievements

Each aspect's score is combined using the corresponding *weights*, which reflect a professional perspective on the relative importance of the two aspects. They were refined, during testing, to ensure that appropriate outcomes were achieved for different patterns of evidence. The overall score is measured against two outcome thresholds: 85% for *competency*, and 65% for *partial competency*.

It is worth noting that when employees, as opposed to students, are assessed against SFIA, all that is usually sought is evidence demonstrating the repeated application of skill components; other aspects, including reflection and manager or supervisor confirmation, are usually probed in an interview. By requiring evidence for each of these additional criteria, the scoring scheme described here offers a robust mechanism for basing the assessment on an individual's artifact, such as a portfolio.

Table 2. Scoring scheme for Technical Achievement and Reflection evidence

Evidence present	*Criteria satisfied*	*Score*
All items	100%	4
	75%	3
	50%	2
	< 50%	1
1 item missing	100%	2
	> 50%	1
2+ items missing	-	0

3.4 Tool Support

The logic of the scoring scheme has been implemented in an Excel spreadsheet[1]. For each scoring items – items of evidence and quality criteria - apart from the first two quality criteria for technical achievement, there is a simple drop-down menu with the options "Y" and "N" (for "yes" and "no", respectively). For the two quality criteria that capture *how many* of the skill components have been demonstrated more than once, there is a data entry area in the tool, reproduced in Table 3. This area must first be populated with the required SFIA skill components, by selecting the skill category and title from two linked drop-down lists. Once the skill has been chosen, the relevant components appear in the left column. To the right are three columns that allow for the entry of references to portfolio items demonstrating the application of the relevant components; these can be of any format, but should be resolvable references if there is a need to audit the assessment. To the right of the data entry columns are two columns, counting the number of item references against each component, and whether or not that component has been demonstrated more than once.

Table 3. Data entry table

Category: **Development and implementation**
Skill: **User experience analysis (UNAN)**

Component	*Entry1*	*Entry2*	*Entry3*	*Count*	*OK?*
Applies standard techniques and tools for developing user stories and eliciting user experience requirements.	7 Jan	23 Feb	13 Mar	3	OK
Organises and structures user experience analysis.	21 Jan	23 Feb		2	OK
Works with stakeholders to prioritise requirements and resolve conflicts.	6 Mar			1	

The SFIA skill, *User experience analysis*, shown in Table 3, is one of 28 skills defined at level 3 in the *Development and implementation* category and has three components. Since the requirement is for more than one entry per component ("*There is more than one portfolio entry...*", only two portfolio item references are required for each component for it to be demonstrated. The data entry area currently allows three to be entered, to satisfy the "multiple entries for each component" criterion. Although students should record all of their achievements in their portfolio, however many times they complete a particular skill component, an assessor needs to identify and enter references only for a maximum of three portfolio entries for each component. In this particular case, two of the three components have been demonstrated more than once, so the second quality criterion in Table 1 has been satisfied (two out of three is greater than 50%), but the first has not. The tool therefore sets the flag for the first criterion to "N", and that for the second to "Y". If all items of evidence are present in the portfolio, and all the remaining criteria are satisfied, this case would correspond to example (b) in Table 4, and the outcome would be "Partially Competent".

[1]Tool downloadable from https://github.com/assessing-computing-competencies

4 TESTING

The goals of testing the assessment approach is to ensure the assessment's *validity*, *practicality* and *effectiveness* [19]. Thus the testing establishes that the assessment is consistent with its intended outcomes and can be implemented, and that portfolios assessed using the proposed scoring scheme will evidence the intended outcomes. The need for, and application of, testing is integral to overall technical competency assessment.

To address validity and effectiveness, the requirements and implementation of the assessment approach were challenged, as they were developed. A range of test cases were generated, outlined in Section 4.1. Using the tool described in Section 3, possible portfolio profiles were reviewed against the test cases. A key selection of these examples is shown in Section 4.2.

4.1 Test Cases

The following test cases were identified to confirm that the overall assessment requirements were generally met.

(1) Verified portfolio items are required to achieve partial competency or competency;
(2) Basic reflection is required for achieving partial competency;
(3) Meeting the 85% quality criterion can be sufficient to achieve competency;
(4) Reflection, recognition of personal development, and appreciation of personal/professional responsibility are all required to achieve competency
(5) A bare minimum of verified portfolio entries can be sufficient to achieve partial competency.

4.2 Test Results

Competency must be demonstrated by multiple portfolio entries, including basic reflection and recognition of personal development and professional responsibility. Supervisor input is crucial, and necessary to validate the achievement of either competency or partial competency. The absence of appropriate entries in a portfolio should generally be regarded as not having demonstrated the corresponding characteristics.

Applying the scoring scheme to portfolios with different profiles results in an appropriate range of outcomes, as summarized in Table 4. The total score is calculated as the sum of the technical score (S_T) and reflection score (S_R) multiplied by their respective weights ($W_T(=16)$ and $W_R(=9)$), that is, $S_T \times W_T + S_R \times W_R$.

Table 4. Example outcomes for different portfolio profiles

Portfolio profile	**TA score**	**Refl. score**	**total score**	**Out-come***
(a) Portfolio entries evidence-based, covering all skill components, validated and contextualised by supervisor; evidence-based reflective entries highlighting impact of personal development and noting professional accountability	4	4	100	C
(b) As (a), but no evidence of reflection in portfolio	4	0	64	NYC
(c) As (a), but multiple entries for only two out of three components	3	4	84	PC
(d) As (a), but no commentary on *professional accountability*	4	2	82	PC
(e) As (a), but multiple entries for only two out of three components, and no reflection on personal/professional responsibility	3	2	66	PC
(f) As (a), but no *supervisor validation* or *contextualization*	2	4	68	PC

*C = Competent; PC = Partially Competent; NYC = not yet competent

In Table 4, example (a) is the baseline - all items of evidence present, and all criteria satisfied, leading to the "Competent" outcomes. Example (b) shows that, in the absence of reflection, but with all other requirements satisfied, the outcome is "Not competent yet", satisfying test case (2). Example (c) satisfies test case (3) as the only criterion not satisfied is for demonstration of 85% of the skill components. Example (d) satisfies test case (4), as just one of the three reflection items of evidence is absent. Example (e) is one of a handful of possibilities for a "bare minimum" of validated portfolio entries which can satisfy test case (5).

Example (f) is more interesting. Although the outcome is "Partially competent", which violates test case (1), that outcome would not be achieved if any other evidence were missing or criteria not satisfied. It follows that this provides a narrow "escape route" for otherwise excellent students caught in the (not impossible) situation that the workplace supervisor does not cooperate by validating the portfolio. Such a stringent loophole would seem, from an academic perspective, to be a reasonable exception to the requirements.

These examples emphasize that students must show both completion of all technical skill components and also basic reflection to achieve competency, with the lesser recognition of partial competency being available to those who have fallen short for one or two criteria. This confirms both the *validity* and *effectiveness* of the approach. *Practicality* is demonstrated both by the existence of the tool and by the established use of portfolio-based assessment on university work-based learning modules.

5 DISCUSSION

Having established a need for the assessment of students' real-world IT competence, we have presented an approach to evaluating the content of a portfolio recording 1) the student technical achievements gained from work-based experiences; and 2)student reflection on those experiences. The assessment approach was developed between 2019 and 2021 as part of the UK Institute of Coding [2], through incremental prototyping informed by expert review. Several of the experts were consultants associated with the SFIA Foundation, who endorsed the approach as it crystallized.

The resulting product was not only the assessment approach and scoring scheme presented in Section 3, but also worked examples, processes, and validation tests, the last being introduced in Section 4. Our work situates the assessment approach within a broader and enhanced academic context, to introduce a support tool that implements the scoring scheme in an Excel spreadsheet, and makes that tool available to interested researchers.

5.1 Issues and Limitations

The checks summarized in Section 4 informed the high-level parameters of the assessment approach. These parameters include relative weights for technical achievement and reflection, and thresholds for"Partial Competency" and "Competency". The parameters characterize a pragmatic configuration designed for valid criterion-based outcomes. The pattern of possible outcomes indicated a highly close match to the shared expectations of the three groups providing expert review: academics, employers, and SFIA consultants. A risk however remains that a different group of experts might agree on slightly different parameter values and outcome profiles.

For example, given that most SFIA skills at Level 3 have 2, 3, or 4 components, the 85% threshold may seem arbitrarily high, meaning, in effect, *all* the components must be demonstrated to achieve competence, except for the handful of skills with five components. However, the 85% and 50% quality criteria 1 correspond to long-established practice among SFIA practitioners, and there was little justification for deviating from those values. Similarly, it was agreed by all the experts that "technical achievement" should be given greater weight than "reflection", but that the latter was not insignificant; hence a ratio of 16:9 was chosen, or roughly 2:1.

One overriding concern was to ensure that assessment using the approach presented in this paper, based exclusively on the content of a portfolio and the supervisor's validation, should lead to outcomes broadly similar to those using the more traditional (and more expensive) interview-based approach. A second concern was to ensure that there would still be a path to some form of recognition for the outstanding student who was let down by their supervisor. Case (d) in Table 4 (just) satisfies this need.

To allow users of our tool to experiment with the configuration, the parameters default to the values presented herein. They can be modified, but systematic checks, as in Section 4, should be applied to any alternative configuration.

Finally, the architecture of the assessment tool is limited by the presentation of the SFIA framework. Over the years, the SFIA Foundation has avoided presenting skill descriptions as bulleted lists, fearing that they would be used as checklists rather than as descriptions. Consequently, users would not approach SFIA skills descriptions with the intentionality discussed in this paper. Thus, some of the skill components deduced from the current version of SFIA (v8) are not granular enough and actually combine multiple distinct technical skills. Should future versions of SFIA present the skills with different granularity, the tool's scoring scheme may need to be adjusted.

5.2 Responsibility (Professional) Characteristics

To be fully competent in a Level 3 SFIA skill, a student's portfolio entry must both satisfy the requirements for one or more technical skills and provide evidence for demonstrating the responsibility characteristics at SFIA Level 3. There are 24 responsibility characteristics defined at SFIA Level 3, grouped under five broad attributes of *autonomy*, *influence*, *complexity*, *business skills* and *knowledge*.

It would in principle be possible to use a scoring scheme similar to that for IT professional competence in Section 3.3. A slightly different approach is needed, however, given that responsibility characteristics are not organized into components like SFIA skills. Another difference is that responsibility characteristics represent dispositional competencies that are cultivated over time through deliberate practice. It is not necessarily the completion of task that develops a dispositional competency, but the nature of engagement in the task. The assessment requirement is still to map portfolio entries to the characteristics that are being demonstrated. However, for the responsibility characteristics, the focus is on repeated *demonstration* rather than *successful task completion*.

An assessment tool for the responsibility characteristics is described in [1, 3]. The tool counts the portfolio entries corresponding to each responsibility characteristic and performs calculations to determine if a responsibility characteristics threshold has been met. Our tool for assessing technical competence is to be used in conjunction with that in [3] to produce a robust overall judgment on the competence of a student, as evidenced by their portfolio. The two tools are consistent, as they are both based on mapping portfolio entries to elements of SFIA.

6 CONCLUSION

The contributions of this paper are three-fold. First, we examined the space of competency-based education for IT students, motivating its need and relevance. Second, we focused on how these IT professional competencies can be assessed using a portfolio-based approach to establish completeness, repeatability, and proficiency. Third, we examined test cases to validate the approach used and to demonstrate its effectiveness and practicality.

There is a renewed focus on preparing computing students for successful long-term careers with employer engagement. Players outside traditional academia are developing future IT talent. For instance, Google Career Certificates [8] prepare students for certifications in IT fields, such as IT Automation, IT Support, Project Management, and UX Design. Traditional academia is also entering this market, e.g., Georgia Tech [7] offers boot camps or certificates in Project Management, Cybersecurity, Cyber and Network Security, UX/UI, and Test & Evaluation. For both traditional and non-traditional educational entities and services, the practical assessment described in this paper represents a useful approach to assessing IT competencies.

ACKNOWLEDGMENTS

Raj and Sabin acknowledge support by the National Science Foundation under Awards 1922169 and 2110771, and 2110823 and 2216031, respectively. The UK Institute of Coding, for which Bowers led the accreditation workstream, received funding from the UK Department for Education.

REFERENCES

[1] David Bowers and Mihaela Sabin. 2022. Using a Professional Skills Framework to Support the Assessment of Dispositions in IT Education. In *SIGITE '22* (Chicago, IL, USA). Association for Computing Machinery, New York, NY, USA, 103–109. https://doi.org/10.1145/3537674.3554747

[2] David S. Bowers, Alan Hayes, Tom Prickett, Tom Crick, Kevin Streater, and Chris Sharp. 2023. The Institute of Coding Accreditation Standard: Exploring the Use of a Professional Skills Framework to Address the UK Skills Gap. In *The United Kingdom and Ireland Computing Education Research conference (UKICER)*. ACM, Swansea, UK, 7 pages.

[3] David S. Bowers and Mihaela Sabin. 2023. Demonstrating the Use of a Professional Skills Framework to Support the Assessment of Dispositions in IT Education. *Education and Information Technologies* 28 (2023), 42 pages. https://doi.org/10.1007/s10639-023-11933-z.

[4] David S. Bowers, Mihaela Sabin, Rajendra K. Raj, and John Impagliazzo. 2022. Computing Competencies: Mapping CC2020 Dispositions to SFIA Responsibility Characteristics. In *2022 IEEE Global Engineering Education Conference (EDUCON)* (Tunis, Tunisia). IEEE, New York, NY, 428–437.

[5] Alison Clear, Allen Parrish, John Impagliazzo, Pearl Wang, Paolo Ciancarini, Ernesto Cuadros-Vargas, Stephen Frezza, Judith Gal-Ezer, Arnold Pears, Shingo Takada, Heikki Topi, Gerrit van der Veer, Abhijat Vichare, Les Waguespack, and Ming Zhang. 2020. *Computing Curricula 2020 (CC2020): Paradigms for Future Computing Curricula*. Technical Report. ACM/IEEE, New York.

[6] L. Dee Fink. 2013. *Creating significant learning experiences: An integrated approach to designing college courses*. John Wiley & Sons, San Francisco.

[7] Georgia Tech Professional Education. 2023. Professional Certificates. https://pe.gatech.edu/certificates.

[8] Google, Inc. 2023. Learn job-ready skills with Google Career Certificates. https://grow.google/intl/en_in/certificates/.

[9] Gerald Grant, Peter Elbow, Thomas Ewens, Zelda Gamson, Wendy Kohli, William Newmann, Virginia Olesen, and David Resman. 1979. *On competence: A critical analysis of competency-based reforms in higher education*. Jossey-Bass, San Francisco.

[10] Richard W. Herling. 2000. Operational definition of expertise and competence. *Advances in Developing Human Resources* 5 (2000), 8–21.

[11] ISO. 2019. *ISO/IEC 24773-1:2019 Software and systems engineering — Certification of software and systems engineering professionals — Part 1: General requirements*. Standard. International Organization for Standardization, Geneva, Switzerland.

[12] Elizabeth Jones. 2013. Practice-based evidence of evidence-based practice: professional practice portfolios for the assessment of work-based learning. *Quality in Higher Education* 19, 1 (2013), 56–71. https://www.tandfonline.com/doi/full/10.1080/13538322.2013.772467.

[13] Jan McArthur. 2022. Rethinking authentic assessment: work, well-being, and society. *Higher Education* 85 (2022), 85 – 101. https://doi.org/10.1007/s10734-022-00822-7

[14] David McClelland. 1973. Testing for competence rather than for intelligence. *American Psychologist* 28 (1973), 1–14.

[15] Jay McTighe and Steve Ferrara. 2021. *Assessing Student Learning by Design*. Teachers College Press, Columbia University, New York.

[16] George E. Miller. 1990. The assessment of clinical skills/competence/performance. *Acad. Medicine* 69 (1990), S63–S67. Issue 9 Suppl.

[17] Martin Mulder. 2014. Conceptions of Professional Competence. In *International Handbook of Research in Professional and Practice-based Learning*, S. Billett, C. Harteis, and H. Gruber (Eds.). Springer, Springer, Dordrecht.

[18] National Research Council. 2012. *Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century*. The National Academies Press, Washington, DC. https://doi.org/10.17226/13398

[19] Nienke Nieveen. 1999. Prototyping to Reach Product Quality. In *Design Approaches and Tools in Education and Training*. Springer, Dordrecht, 125–135.

[20] Rajendra K. Raj, Mihaela Sabin, John Impagliazzo, David S. Bowers, Mats Daniels, Felienne Hermans, Natalie. Kiesler, Amruth N. Kumar, Bonnie MacKellar, Renee McCauley, Syed W. Nabi, and Michael Oudshoorn. 2021. Professional Competencies in Computing Education: Pedagogies and Assessment. In *2021 ACM Conference on Innovation and Technology in Computer Science Education Working Group Reports (ITiCSE WGR '21)*. ACM, New York, 133–161. https://www.doi.org/10.1145/3502870.3506570.

[21] Mihaela Sabin, Hala Alrumaih, John Impagliazzo, Barry Lunt, Ming Zhang, Brenda Byers, William Newhouse, Bill Paterson, Svetlana Peltsverger, Cara Tang, Gerrit van der Veer, and Barbara Viola. 2017. Information Technology Curricula 2017 (IT2017). https://dl.acm.org/doi/pdf/10.1145/3173161.

[22] Elizabeth J. Simpson. 1972. *The classification of educational objectives, psychomotor domain*. Gryphon House, Washington D.C.

[23] Lyle M. Spencer Jr. and Signe M. Spencer. 1993. *Competence at work: Models for superior performance*. John Wiley, New York.

[24] Angela Stoof, Rob L. Martens, Jeroen J.G. van Merrienboer, and Bastians Theo J. 2002. What is competence? A constructivist approach as a way out of confusion. *Human Resource Development Review* 1, 3 (2002), 345–365.

[25] The SFIA Foundation. 2021. SFIA - Skills at a Glance. https://sfia-online.org/en/sfia-8/sfia-views/full-framework-view?path=/glance.

[26] The SFIA Foundation. 2021. SFIA - Skills Framework for the Information Age. https://sfia-online.org/en/.

[27] Grant Wiggins. 1998. *Educative Assessment: Designing Assessments to Inform and Improve Student Performance*. Jossey-Bass, San Francisco.

[28] Grant P. Wiggins and Jay McTighe. 2005. *Understanding by Design*. Association for Supervision and Curriculum Development, Alexandria, VA.