The Institute of Coding Accreditation Standard: Exploring the Use of a Professional Skills Framework to Address the UK Skills Gap

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ABSTRACT

Computing comprises a broad spectrum of subjects and specialisms, with a rich variety of undergraduate courses (including Computer Engineering, Computer Science, Cybersecurity, Information Systems, Information Technology and Software Engineering) offered by universities worldwide. This breadth presents challenges for employers considering employing computing graduates and hence desiring to know both the topics studied and the skills/competencies accumulated by graduates to be able to make appropriate job offers. Small to medium enterprises (SMEs) may not have the resources to provide graduate training programmes, and therefore need 'work-ready' graduates.

This paper explores and evaluates the feasibility of benchmarking students' achievements against an industry-led skills framework, *Skills for the Information Age* (SFIA), to distinguish between what graduates know, have done or are competent in. The approach taken was evolutionary prototyping, informed by expert review. The work generated an accreditation standard that could be implemented or used as a model to enhance an existing accreditation standard. In contrast to academic approaches to competency-based education, or abstract notions of generic skills, this work focused on defining an output standard expressed in terms of employer needs and expectations captured in the SFIA skills framework. We show how a course meeting the proposed standard would satisfy the UK benchmarks for an undergraduate computing degree. By badging SFIA knowledge and competencies, such a course would enhance its learning outcomes, offering clarity for employers and career benefits to students.

CCS CONCEPTS

• **Social and professional topics → Computing education**;

KEYWORDS

IT competencies, accreditation standard, skills frameworks, SFIA

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1 ADDRESSING THE SKILLS GAP

Graduate employment prospects are multifaceted. Graduate professional skills are an important contributor [14, 29, 56]. In addition to human capital (which is seen as skills, professional skills, and work experience), social capital (networks, social class and University ranking), individual attributes, individual behaviours (career self-management and career-building skills), perceived employability and labour market factors have all been argued to impact graduate employability [14]. Increasing professional competencies has been argued to improve the employability of computing graduates [20, 21, 25, 44, 45, 52].

Accreditation can be defined as: "*1. the act of giving official authority or approval or the resulting status; certification; 2. the act of certifying an educational institution or program as meeting all official formal requirements of academic excellence (e.g., facilities, curriculum, faculty); or 3. the act of attributing or ascribing some quality, status, or action to a person or thing*" [27]. Computing degree accreditation regimes are intended to promote employability by promoting the expected learning required for professional practice [18, 19, 23, 25, 33]. A recent ACM ITiCSE Working Group explored and recommended models for professional accreditation that embed competency [44], and doing so is the focus of this paper.

In UK higher education, all disciplines develop the skills expressed in the "higher" levels of Bloom et al.'s (cognitive) taxonomy – analysis, synthesis, evaluation [2]. For most computing graduates in the UK, this is sufficient to obtain work or further study [44]. However, unemployment and underemployment of computing graduates remain higher than is desirable (in 2019-20 88% employed or in full-time study with a further 8% unemployed with similar or less favourable outcomes being seen internationally) [44].

A UK Government report commissioned to review the accreditation of computing degree programmes and barriers to graduate employment noted that, despite the employment gap,"performance of Computer Sciences graduates from English Higher Education Institutions is outstanding, and the majority of graduates go on to fulfil important and rewarding jobs" [48, p. 3]. The report [48] highlighted barriers to graduate employment suggesting, "the supply of Computer Sciences graduates and the needs of employers appear in some way misaligned, [with] a complex interrelationship between supply and demand" [48, §2.2] and that, "There are a number of commonly reported issues, with graduates lacking work experience and commercial awareness, a lack of soft skills and insufficient technical knowledge among those most often quoted." [48, §2.9]. The skills gap between employer expectations and graduates' skills is well documented and reported to be global [16]. Informally and pessimistically, this is expressed in terms of some (computing) graduates being unready to do anything actually useful in the workplace – they have to be upskilled, even if they have moderate degree grades.

These challenges are also highlighted in the ACM/IEEE Computing Curricula 2020 Paradigms for Global Computing Education (CC2020) guidelines[12]. The CC2020 guidelines encourage a competency-based approach where "A competency specification enumerates knowledge, skills, and dispositions that are observable in the accomplishment of a task, a task that prescribes purpose within a work context" [12, p. 47]. Knowledge is seen as "know-what", skills are seen as "know-how", and dispositions are individual behaviour patterns ("human-skills"); these three aspects are applied to a live or simulated real-world computing task. This approach aims to develop computing graduates for professional practice better and ease their transition into the workplace. The Skills for the Information Age (SFIA) [53] presents an alternative model for competency. The building blocks in SFIA are professional skills and generic attributes. The generic attributes describe knowledge and behaviour attributes that, combined with professional skills when employed repeatedly in a real-world context, evidence competence. The existing learning outcomes required for accreditation by BCS, The Chartered Institute for IT include both technical skills and some behavioural characteristics, as well as some aspects of commercial awareness. The recognition of real-world competencies (gained in work placements or similar activities) is provided by Registration of IT Technicians (RITTech) [4]. RITTEch is based around SFIA. However, considering competency in a manner advocated by either the CC2020 or SFIA models is less complete in the main accreditation credentials (i.e. CITP and CEng).

Finally, there is a clear post-COVID pandemic framing for the scrutiny of graduate skills and employability, both for UK universities [17, 62, 63], and specifically for the computing disciplines [22, 49]. This paper thus explores the generation of an accreditation scheme around an existing competency model and, in doing so, seeks to address the following research question: *Is it possible to base an accreditation standard on a professional skills framework, as one approach to addressing the skills gap?*

2 BACKGROUND

Focusing an accreditation standard on competency rather than just on knowledge and skills would provide graduates with evidence that they have demonstrated capabilities valued by employers. Thus, employers would know what recruits should be able to do almost immediately upon taking up employment. To demonstrate competence, they would need to have gained real-world work experience and developed commercial awareness, soft skills and relevant technical knowledge, all as part of their degree.

ISO24773 [34] defines Competence in Computer and Software engineering as, "Competence involves the ability to apply knowledge and skills [...] to achieve a successful result on an ongoing basis [...] apply[ing] sound judgement, mak[ing] correct decisions, apply[ing] the appropriate skills and knowledge and mak[ing] use of relevant professional attributes." Competence replaces neither knowledge nor skills but incorporates and builds on both.

Computing is a broad discipline with a significant impact across the entire spectrum of employment. To develop a new accreditation approach for such a wide-ranging subject, there were two apparent options: to explore the graduate characteristics that should be added to existing learning outcomes to develop graduate competence, as proposed in ACM/IEEE curricular recommendations for IT [46] and in the CC2020 report [15]; or to build on an existing employer-focused skills framework such as SFIA, the Skills Framework for the Information age [53]. SFIA was developed and is maintained by its users, who are overwhelmingly employers. Used in over 180 countries, it is the Computing/IT skills framework most widely used globally. SFIA sets out the activities typically associated with 121 distinct skills in the broad domains of computing and IT, ranging from *high-performance computing* and *data science* to *service-* and *project management*. Skills are defined for seven "levels of responsibility"; the levels range from 1 ("assist") through 3 ("Apply") to 7 ("Set strategy"). The behavioural and interpersonal ("soft") skills required for the effective application of (technical) knowledge and skills to demonstrate competence in any SFIA skill defined at a particular level are expressed as *responsibility characteristics* for that level. One of the key factors leading to the adoption of SFIA for this paper is that, unlike in other skills frameworks, the responsibility characteristics are defined separately from technical skillsin SFIA [9]. So, it is possible to define a generic accreditation standard that is not tied to specific topics in computing. SFIA Level 3 is the benchmark for BCS's RITTech [6], the first stage on the ladder towards professional recognition at Chartered level, which is mapped to SFIA Level 5. Level 3 responsibility characteristics correspond to the "dispositions" identified in CC2020 [11], and are appropriate goals for a new graduate.

3 RELATED WORK

Bloom's taxonomy for learning, teaching and assessment [7] and its subsequent revisions (e.g., [2]) have long influenced the development of curricula in general, including those for computing at the university level. The focus of even the most recent revisions of Bloom's taxonomy continues to be on knowledge and understanding rather than on practical achievements, and this has inevitably enhanced the attractiveness of Bloom-derived taxonomies to academic education and, in particular, assessment.

Educators and professional bodies have long recognized the importance of interpersonal and professional skills to supplement academic knowledge. This is reflected in the explicit inclusion of skills such as "teamwork" and "communication" in accreditation requirements by those such as BCS [5]. Furthermore, the recognition of the importance of developing "human skills" to complement academic knowledge led, in the context of pre-university education, to the development of non-disciplinary frameworks such as "21st

Century Skills"(C21 Skills) [36, 39, 58]. Some authors have suggested explicitly incorporating C21 Skills into degree accreditation criteria for computing [60]. However, even adding the professional skills captured by C21 Skills does not completely address the skills gap, which is also concerned with real-world *practical competence*.

Alongside Bloom's original development, Simpson led the development of a corresponding hierarchy for the psychomotor domain [50], which focuses on *repeated practice* to perfect the performance of a task. Although Bloom and his colleagues recognised the existence of the psychomotor domain, it was apparently considered irrelevant to education, even though Simpson believed herself that, "the domain would be of considerable value to educators in several areas of vocational and technical education." As with Bloom's cognitive taxonomy, several authors have sought to develop updated educational taxonomies to support physical skills and coordination in children [26], assessment of practical activities [13] and engineering [31]. It has been shown that the essence of the psychomotor domain – repeated practice – more closely matches the stages of developing competence than does Bloom's cognitive taxonomy, although there is some overlap at the "lower" levels [8]. However, little guidance exists on how repeated practice should be embedded in assessment. But this kind of assessment is common in practice – several management websites (e.g. [16]) suggest how to approach assessing staff competence. In the medical fields, Miller's Hierarchy is used widely [35], combining a foundation of cognition ("know what" and "know how") with higher levels of application ("show how" and "do"). As with the psychomotor hierarchies, an underlying premise is repeated practice to achieve competence, and assessment is based on repeated successful demonstration of tasks.

To build from repeated practice towards assessment, assessment tasks should be realistic. Recent developments in problem-based learning and authentic assessment such as [1, 3, 57] offer opportunities here, but the realism and benefit could be lost if the final stages of an "authentic" assessment task were to regress to "cognitive" tasks such as reflection. Indeed, a risk associated with incorporating competence into computing curricula is that what is incorporated is an *academic abstraction* of competence, such as reflection on performance, rather than the *demonstration* of professional competence.

The first academic competency framework in the computing area that explicitly included professional skills was the software engineering competency model (SWECOM) [32]. These principles were developed in the 2017 ACM/IEEE Information Technology curricular recommendations [47]. The subsequent Computing Curricula 2020 report (CC2020) [15], which was developed concurrently with this project, made the major recommendation to shift the emphasis for *all* "computing" baccalaureate programs from bodies of knowledge to competency, with competency modelled as knowledge + skills + "dispositions".

The publication of CC2020 spurred a flurry of explorations of the assessment of the 11 dispositions identified in the report: see, for example, [44, 45]. In parallel activity, it was demonstrated [11] that the CC2020 dispositions were effectively equivalent to the responsibility characteristics specified for Level 3 of the SFIA framework [54].

4 RESEARCH APPROACH

We report in this paper proof-of-concept research [28] conducted by evolutionary prototyping [51] informed by expert review. The aim was to develop a detailed accreditation standard from an initial idea, refining the details iteratively to ensure *validity*, *practicality* and *effectiveness* [37] – that is, ensuring that the standard was consistent with its intended outcomes, could be implemented and that programmes satisfying the standard would lead to the intended outcomes. As the standard was developed within the IoC, the term *IoC standard* is used to refer to the standard developed.

The research took place within the Institute of Coding (IoC), established in 2018 [24, 25] as part of the UK national response to the Shadbolt Review [48]. The IoC's mission was to, "break down barriers to digital learning and employment." [38]. The IoC consortium comprised over 100 employers and around 30 Universities. The IoC mission included addressing the "bloc of opinion" cited by Shadbolt by designing a new accreditation standard for Computing Degrees that would address the "commonly reported issues" identified by Shadbolt. The work was completed between 2019 and 2021.

Initial ideas were explored in workshop sessions to confirm high-level requirements and identify potential areas of concern. Workshop participants included academics (who would be responsible for delivering any degree programme conforming to the standard) and employers (who would be the effective consumers). Expert review of the increasingly complete draft standards was provided by an "accreditation panel". Similarly to the initial workshops, members included academics (8), employers (6), representatives from the relevant professional bodies (BCS and IET) (3) and – since the standard was to focus on professional computing skills – skills professionals from the SFIA community (2). The leadership of the panel was shared between an academic and an industrial co-chair. The academic panel members included leaders for the overall IoC themes (*university learners*, *the digital workforce*, *digitalising the professions*, *widening participation* and *knowledge sharing & sustainability*) [24]. The employer members included a sole trader consultant, SME directors and senior staff from multinationals.

The panel met roughly monthly over two years. Proposals for refinements to the draft standard were circulated, and panel members were invited to engage in a joint critical review in panel meetings. The critical reviews confirmed the thrust of the initial proposals and guided and modified incremental details as they were added.

In most cases, the reviews endorsed the standard's current draft (prototype) and indicated the next area(s) for refinement. In other cases, shortcomings in the current draft were identified, leading to improvement suggestions. For example, insufficient emphasis was found in the SFIA (v7) responsibility characteristics for Legal, Social, Ethical and Professional issues (LSEPIs - required for professional body accreditation); so these were added to the draft standard as an explicit requirement. Similarly, the benchmark assessment of the evidence for the demonstration of a particular skill was revised significantly to include explicit reflection and evidence of personal development and professional responsibility.

The review process was bi-directional, particularly for employer members of the panel. Some employers were concerned by the standard requiring competence and underpinning knowledge for only four professional skills. A detailed review of an example "Web Design" curriculum, developed to confirm the practicality of the standard, demonstrated that graduates would need a traditional broad foundation followed by progressive specialisation to achieve the skills and knowledge required for the standard. This would inevitably include exposure to and development of a range of skills (at lower SFIA levels) in the early stages of their degree.

Graduates' achievements from the example curriculum being represented as a collection of SFIA badges reassured employers about the effectiveness of the standard, in terms of outcomes, and academics about its practicality. Academic members of the IoC consortium, including those represented on the panel, were invited to consider how their own degree programmes might be modified to meet the standard, and to share outline submissions for accreditation against the standard. The four universities which made such submissions found few problems, apart from one which could not meet the standard because the submission asserted that classroom knowledge and skills were equivalent to real-world competence.

An important component of prototyping is testing to ensure the validity and effectiveness of the emerging design. Testing – by worked examples – was embedded into the process whenever sufficient features had crystallized for testing to be useful. Test reports were considered in panel reviews, and published on the projects' GitHub repository. These reports contributed to the approval or revision of each prototype as the design matured. The panel endorsed unanimously the final versions of the accreditation standards, the associated accreditation processes and benchmark assessments.

5 PROPOSAL: A COMPETENCY-BASED ACCREDITATION STANDARD

For a bachelor's degree with honours (corresponding to a "first cycle end of cycle qualification" in the European Qualification Framework), the normal requirements for level and volume would apply, as set out in [40, p8]: 360 CATS credits ($\approx$ 3600 hours of study), with at least 90 at FHEQ [42] Level 6. Programmes accredited under the standard would also need to demonstrate that they embedded significant opportunities for students to gain real work-based experience. The standard required graduates to demonstrate real-world *competence*, benchmarked against the global SFIA skills framework [53].

The essence of the standard was that graduates from a bachelor's programme should demonstrate knowledge to support at least four SFIA skills at SFIA levels 3 and 4, and competence in at least one skill at SFIA Level 3. To ensure compatibility with current BCS accreditation requirements [5], graduates should also demonstrate understanding of, and engagement with, legal, social, ethical and professional issues (LSEPIs), including diversity, inclusion and sustainability. For Master's degrees, the requirement was for knowledge to underpin three skills at SFIA Level 4 or 5, and competency in at least one skill at SFIA Level 4. To allow for constraints on students' circumstances that may preclude opportunities to apply knowledge and skills across the full breadth of their selected SFIA skill, an intermediate level of "proficiency", or "partial competency", would be acceptable in place of either competency requirement.

Graduates would be awarded digital badges for knowledge, proficiency or competency for SFIA skills at particular levels, providing a novel transcript that would be immediately relevant for employers. In order to develop knowledge and skills to underpin competence in a SFIA skill at Level 3, it would be likely that students would also have developed knowledge or competency in supporting skills at SFIA levels 1 or 2. So, a "transcript" for a graduate from the "Web Design" curriculum mentioned in Section 4 would include a set of digital IoC/SFIA badges. These badges would range from a competency badge for "PROG" (L4) *Programming and Software Creation* to a knowledge badge for "HCEV" (L2) *User Experience Design*. The IoC/SFIA badges would conform to the Open Badge Standard, each linked to its skill descriptions.

Alongside the specification of the standards are principles for a new accreditation process and a benchmark assessment method. The former sets out the expectations for accreditation, which focus on an institution's assessment of *proficiency* and *competency*, requiring that the evidence (portfolios) assessed for a sample of students be submitted for review, and that the institution's assessment outcomes be broadly similar to those using the IoC's benchmark. The assessment benchmark addresses three aspects of a student's experience, recorded in a portfolio: successful repeated completion of activities for a particular SFIA skill at a specified level; reflection on those technical achievements; and demonstration of the SFIA responsibility characteristics for the relevant level [54]. To provide flexibility and agility for institutions, the accreditation process focuses only on the validation of their assessment of proficiency and competency, and not on specific course content, beyond that it must support the development of knowledge and skills to underpin several SFIA skills at the appropriate levels.

6 EVALUATION

A degree accredited against any accreditation standard must meet relevant regulatory requirements. Given the flexibility of the IoC standard, for which the demonstrated competencies, skills and knowledge can be selected from any of the skills defined in SFIA at Levels 3 or 4, the only common outcomes for all accreditable degree programmes are the demonstration of SFIA Level 3 or 4 responsibility characteristics. The SFIA responsibility characteristics were mapped against the relevant frameworks and standards current at the time namely: the 2014 QAA Frameworks for Higher Education Qualifications of UK Degree-Awarding Bodies (FHEQ) [42]; 2016 QAA subject benchmark statement for computing[43]; 2011 QAA subject benchmark statement for Master's degrees in computing [41]; 2020 BCS Guidelines on course accreditation (for CITP) [5]; and the requirements for HEI accreditation for RITTech [4]. The complete set of mappings are too long too include here, but Table 1 shows the mapping from the FHEQ Outcome Descriptors for a Bachelor's degree to the SFIA Level 3 responsibility characteristics. Each outcome descriptor is shown as being satisfied in full (SF), in part (SP), with a suitable technical context (ST), or not addressed (NA). The responsibility characteristic(s) contributing to each outcome are shown in the rightmost column of the table.

An IoC accredited bachelor's degree requires study to FHEQ Level 6, so the FHEQ characterisation of this level of study is relevant: "[Graduates] will have developed an understanding of a complex body of knowledge, some of it at the current boundaries of an academic discipline. Through this, [graduates] will have developed analytical techniques and problem-solving skills that can be applied in many types of employment. [Graduates] will be able to evaluate evidence, arguments and assumptions, to reach sound judgements and to communicate them effectively." [42, §4.15.1]

In Table 1, two outcomes are not addressed by the generic responsibility characteristics, and one is addressed only partially. Specifically, the generic characteristics alone do not address:"c.ii. to

Table 1: Alignment between FHEQ outcomes descriptors for a Bachelor's degree and SFIA Level 3 responsibility characteristics

	Bachelor's degree with honours are awarded to students who have demonstrated:		**Supporting SFIA responsibility characteristics**
a	a systematic understanding of key aspects of their field of study, including acquisition of coherent and detailed knowledge, at least some of which is at, or informed by, the forefront of defined aspects of a discipline	ST	Has a sound generic, domain and specialist knowledge necessary to perform effectively in the organisation typically gained from recognised bodies of knowledge and organisational information.
b	an ability to deploy accurately established techniques of analysis and enquiry within a discipline	ST	Demonstrates effective application of knowledge.
c	conceptual understanding that enables the student:		
c1	- to devise and sustain arguments, and/or to solve problems, using ideas and techniques, some of which are at the forefront of a discipline	ST	Applies methodical approach to issue definition and resolution; Demonstrates an analytical and systematic approach to issue resolution.
c2	- to describe and comment upon particular aspects of current research, or equivalent advanced scholarship, in the discipline	NA	
d	an appreciation of the uncertainty, ambiguity and limits of knowledge	NA	
e	the ability to manage their own learning, and to make use of scholarly reviews and primary sources (for example, refereed research articles and/original materials appropriate to the discipline).	SF	Takes action to develop own knowledge. Takes the initiative in identifying and negotiating appropriate personal development opportunities.
	Typically, holders of the qualification will be able to:		
f	apply the methods and techniques that they have learned to review, consolidate, extend and apply their knowledge and understanding, and to initiate and carry out projects	ST	Applies methodical approach to issue definition and resolution. Demonstrates an analytical and systematic approach to issue resolution. Takes the initiative in identifying and negotiating appropriate personal development opportunities.
g	critically evaluate arguments, assumptions, abstract concepts and data (that may be incomplete), to make judgements, and to frame appropriate questions to achieve a solution - or identify a range of solutions - to a problem	SP	Has an appreciation of the wider business context. Demonstrates an analytical and systematic approach to issue resolution.
h	communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.	SF	Has working level contact with customers, suppliers and partners. Has an appreciation of the wider business context. Demonstrates effective communication skills.
	And holders will have:		
i	the qualities and transferable skills necessary for employment requiring:		
i.i	- the exercise of initiative and personal responsibility	SF	Works under general direction. Uses discretion in identifying and responding to complex issues and assignments. Receives specific direction, accepts guidance and has work reviewed at agreed milestones. Appreciates how own role relates to other roles and to the business of the employer or client.
i.ii	- decision-making in complex and unpredictable contexts	SF	Performs a range of work, sometimes complex and non-routine, in a variety of environments. Applies methodical approach to issue definition and resolution. Demonstrates an analytical and systematic approach to issue resolution.
i.iii	- the learning ability needed to undertake appropriate further training of a professional or equivalent nature.	SF	Takes action to develop own knowledge. Takes the initiative in identifying and negotiating appropriate personal development opportunities.
Key:			
SF	Satisfied in full	ST	Satisfied given appropriate technical context
SP	Satisfied in part	NA	not addressed

describe and comment upon particular aspects of current research, or equivalent advanced scholarship, in the discipline;" and "d. an appreciation of the uncertainty, ambiguity and limits of knowledge." However, given the FHEQ characterisation of academic study at Level 6, and that a degree satisfying the IoC standard would include learning at Level 6, these two outcomes should be satisfied. Similarly, study at Level 6 combines with the generic responsibility characteristics to deliver the partially satisfied outcome: "g. critically evaluate arguments, assumptions, abstract concepts and data (that may be incomplete), to make judgements, and to frame appropriate questions to achieve a solution - or identify a range of solutions - to a problem." The remainder of the outcomes are either satisfied in full or satisfied given a technical context. Since SFIA responsibility characteristics must be demonstrated to achieve competence in one or more SFIA skills, any of which provides a "technical context", outcomes *satisfied with a suitable context* will be satisfied in full when the standard is instantiated with SFIA skills. Hence, an honours degree meeting the IoC Standard would deliver the FHEQ outcomes, meaning that the IoC standard is fully aligned with FHEQ. Furthermore, the outcome of the mapping for each of the other frameworks was broadly similar: most of the non-technical outcomes supported directly by the SFIA responsibility characteristics, and the remainder supported either by the technical context or by the requirement for study at FHEQ level 6, or both.

The processes underpinning the standard were also checked for conformity with ISO24773 and the emerging SFIA assessment processes, and the overall standard was compared with the ACM CC2020 recommendations. The key for the processes was the explicit recognition and separation of knowledge, skills and competence, and for the latter, that the Level 3 responsibility charactersitics are equivalent to CC2020 dispositions [11].

The benchmark assessment process for technical skills is a development of a criterion-based assessment scheme shown to be scalable and consistent when used for a university work-based learning module. That for the responsibility characteristics is similar to that used by BCS for the assessment of RITTech applicants' competencies, but adjusted for assessing a portfolio and to ensure that the standard meets the regulatory frameworks.

Both processes, which have been endorsed by the SFIA Foundation for the award of "competency" badges, assume that students have recorded their experience in some form of portfolio. Accuracy of portfolio entries should be validated by the student's workplace supervisor. Entries are scanned for evidence either of successful completion of technical activities specified within a SFIA skill, reflecting on those successes, or demonstration of SFIA responsibility characteristics for the appropriate level. The "assessment" counts the number of portfolio entries demonstrating each technical activity, reflection or responsibility characteristic, to ensure "repeated successful application of knowledge and skills [...] to demonstrate tasks [...] over a period of time".

In summary, all alignments were confirmed, provided that the knowledge component was delivered by an institution that complies with FHEQ/FQHEIS. It follows that the answer to our research question is that *it is possible* to base an accreditation standard on a professional skills framework. Such a standard could help to address the skills gap by signposting the competencies a graduate can evidence to potential employers and promoting the adoption of competency-based education in Computing degrees.

7 CONCLUSION AND FURTHER WORK

At the time of writing, whilst no professional body plans to incorporate the IoC standard (or variant of it) in their accreditation regimes, there may be opportunities to do so in the future. This would align with the current ACM curricular recommendations that computing programs should focus on competency rather than merely on knowledge and skills. The proof of concept presented in this paper demonstrates the feasibility of the proposed standard. By focusing on competency rather than knowledge and skills, the IoC standard supports a significant proportion of students who may be better at "doing" rather than "writing about" computing (perhaps increasingly relevant in a world of pervasive generative AI tools [30]). Explicit evidence of competency will be welcomed by employers, and help to bridge the perceived "skills gap". Elements of the standard can be re-used. For example, RITTech accreditation requires that students reach SFIA Level 3 during a placement. Hence, programmes adopting the IoC benchmark assessment approach, to award proficiency or competency badges at Level 3, should satisfy the requirements for RITTech accreditation.

Urgent research is now required to explore how competency, as measured in the IoC accreditation standard, can be combined with other relevant factors to improve graduate employment outcomes further. For example, there are several strategies to deploy digital badges and micro-credentials, such as those proposed as part of the IoC standard, alongside or within existing courses [59, 61]. Digital badges for competency which meet the SFIA Foundation's formal competence assessment standards [55] should improve significantly on employers needing to rely on digital badges awarded by vendors, since vendor badges may not require any demonstration beyond mere knowledge and, sometimes, skill.

In addition to academic computing departments developing curricula, potential employers and students are critical stakeholders for this undertaking [19, 20, 25], and their perceptions related to the approach, its future use and potential benefits should also be explored. The IoC approach to assessing competency has evoked significant interest from those working on competency-related pedagogies and assessment in the ACM/ABET community [45]. The equivalence of the *SFIA Level 3 responsibility characteristics* to the *CC2020 dispositions* has been shown [11], and the IoC assessment method applied to assessing dispositions [9, 10].

As discussed in Section 1, computing graduate unemployment and underemployment remain higher than ideal in the UK and many jurisdictions worldwide. It is incumbent on the computing education community to continue exploring how to address this.

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