ICT Skill Frameworks: Do They Achieve Their Goals and Users' Expectations?

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KEY WORDS

ICT, Skills, SFIA, e-CF

ABBREVIATIONS

CCNA - Cisco Certified Network Associate
e-CF - European e-Competence Framework
GSCs – Generic Skills and Competences
ICT - Information and Communication Technology
PRINCE2 – Projects IN Controlled Environments
SF for ICT - Skills Framework for Infocomm Technology
SFIA - Skills Framework for the Information Age
TSCs – Technical Skills and Competences

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What this paper adds:

There has been very little review and analysis of existing ICT skill frameworks in the academic literature. This paper compares three existing ICT skill frameworks with respect to their design choices and feature sets. We then present our opinions on whether these frameworks achieve their goals and the expectations that end users may have. We also identify crucial aspects that none of these frameworks adequately address, in particular portability and automation.

Abstract:

Objective: To examine whether existing ICT skill frameworks achieve their goals and the expectations that end users may have.

Methods: First we examine typical objectives and user expectations of ICT skill frameworks. Then three existing ICT skill frameworks, specifically SFIA, e-CF and SF for ICT, are surveyed and compared with each other in terms of their design choices and feature sets. The implications of some of these design choices are discussed, particularly where there are significant differences between the frameworks or where there are apparent conflicts with objectives or user expectations. We also identify salient features which are missing from all existing frameworks.

Results: The existing frameworks differ in a number of significant areas, including the number of hard skills and the treatment of soft skills. Furthermore, all three frameworks surveyed might be considered somewhat complex in terms of defining skill proficiency using multiple attributes and the intricacy of the skill/proficiency mapping. There is also a lack of unambiguous and universal certification criteria, which limits the portability of the frameworks between organisations. Finally, automation of skills management is also hindered by the fact that the skills are defined in natural language without any specific structure or semantics that could be leveraged by advanced applications.

Conclusions: The significant differences between and the complexity of existing ICT skill frameworks implies that debate is still required about how an ICT skill framework should be designed to be of maximum utility. Existing frameworks need to be extended or complemented to support important use cases around portability and automation.

Introduction: The correct blend of skills, knowledge, experience and other attributes (e.g. cultural fit between employer and employee, honesty, responsibility) is central to employability in any field including Information and Communications Technology (ICT). With respect to skills, we may distinguish broadly between 'domain specific' skills (sometimes referred to as 'hard' or 'technical' skills) and 'domain independent' skills (sometimes referred to as 'soft' or 'transferable' skills) (Andrews and Higson, 2008; Robles, 2012). The terms 'domain specific' and 'domain independent' are used throughout this paper to avoid any confusion since there is some difference of opinion about the exact meaning of 'hard', 'soft', 'technical' and 'transferable' in common usage. An example of a domain specific ICT skill is software testing whereas examples of domain independent skills are communication, leadership and teamwork. While both types of skills are important in the ICT sector, most employers regard domain independent skills as the more important category in professional practice because the success of an organisation as a whole often depends upon the harnessing of these skills (Eisner 2010).

It is with this background and the dynamic nature of the ICT industry that a plethora of ICT skill frameworks and professional certifications have arisen over the past few decades. In principle, skill frameworks define a common terminology and minimum set of requirements for certain skills such that all users of the framework have the same base from which to work. Examples are Skills Framework for the Information Age (SFIA Foundation, 2018), the European e-Competence Framework (European e-Competence Framework, 2018) and Skills Framework for Infocomm Technology (SkillsFuture, 2018). The typical goals of these skill frameworks are to facilitate or simplify the following:

- Assessment of current skill proficiency for individuals
- Identification of target skill proficiency for individuals
- Assessment of current skill portfolios in an organisation
- Identification of skill gaps in an organisation
- Design of accurate job and role descriptions
- Design of training and educational programmes by training/educational providers.

The value proposition is that organisations do not have to develop their own internal ICT skill frameworks from first principles and the common syntax and semantics that such frameworks provide for inter-organisational use.

As partly discussed in Lundqvist et al. (2008), it can be reasonably assumed that the end users of ICT skill frameworks, such as individuals and organisations, would have at least the following expectations of such frameworks:

- *Utility:* clear, comprehensive and useful skill and proficiency definitions covering all major areas of ICT
- *Simplicity:* simple to understand, apply and integrate into overall skills management
- *Portability:* skills validated in one organisation are implicitly accepted by any other
- *Automatability:* advanced skill management tasks, such as parsing a Request for Proposal (RFP) and distilling the skills and associated proficiencies needed to support it, can be automated
- *Trust/Confidence:* adoption of an external framework serves the needs of the user at least as well as an internal proprietary framework developed from first principles.

Unlike frameworks which are usually quite generic in terms of their scope, professional certifications demonstrate a certain level of competency in a specific field, usually assessed by means of a test. They may be vendor specific e.g. Cisco certifications such as CCNA (Cisco, 2018) or vendor neutral e.g. CompTIA certifications such as Network+ (CompTIA, 2018).

There has been very little academic input to or analysis of the emergence and evolution of ICT skill frameworks and professional certifications. Most of the scholarly contributions to skill frameworks have taken place at a more general level not specifically connected with ICT. Clarke and Winch (2006) investigate the difficulty of developing a European wide skill framework given the different definitions of skills and qualifications used in different European countries, and specifically the UK and Germany.

Lundqvist et al. (2008) discuss an ontological approach to skill management in which skills are defined in a formal manner so as to facilitate advanced automation of competency tasks such as job search and skill gap analysis. However, this type of formal approach has not been adopted by any of the major existing ICT skill frameworks as discussed later. Where existing ICT skill frameworks are discussed in the academic literature, it is usually from an implementation perspective rather than an analytic viewpoint. von Konsky et al. (2014) investigate the use of SFIA based tools to inform the design of ICT curriculum in higher education. Tambouris et al. (2012) discuss employing the Enterprise Architecture Competence

Framework (EA-CF), which is based on the European e-Competence Framework, for training purposes.

The purpose of this paper is to consider whether existing ICT skill frameworks achieve their goals and the expectations that end users may have. In particular, the paper explores the following:

- the significant difference in the number of domain specific skills represented in the different frameworks
- how domain independent skills are treated differently in different frameworks
- the utility of employing attributes (e.g. autonomy, complexity) in defining skill proficiency
- the current complexity of skill/proficiency mapping and whether it is justified
- the lack of unambiguous and universal certification criteria that limits portability
- the lack of structure and/or semantics in the skills definitions that limits automation.

Methods: This section discusses the method for surveying three existing leading ICT skill frameworks:

- Skills Framework for the Information Age (SFIA) Version 6 (SFIA, 2018)
- European e-Competence Framework (e-CF) Version 3.0 (European e-Competence Framework, 2018)
- Skills Framework for Infocomm Technology (SF for ICT), an initiative of SkillsFuture Singapore (SSG) and others (SkillsFuture, 2018).

The ultimate aim is to discover and summarise the commonalities of and differences between the frameworks. The frameworks are discussed in just enough detail to support this analysis. It should be noted that there are other ICT skill frameworks e.g. iCD in Japan (IPA, 2018), and so the choice of skill frameworks to consider is somewhat arbitrary, but the three surveyed are all prominent examples. For example, SFIA has been developed over a period of 20 years by a consortium of organisations and has been adopted globally, while e-CF is backed by the European Commission and has been published as a European standard.

The method employed consists of obtaining the publicly available information about the frameworks, primarily from the websites of the organisations promoting the ICT skill frameworks. This information has been classified into various categories (e.g. number of domain specific skills and number of proficiency levels) and then compared and contrasted for the different frameworks. Consideration has also been given to features which appear to be absent from the frameworks based upon the publicly available information, for example features related to portability and automatability. This information is ultimately summarized in tabular form. There then follows a discussion on the implications of these results, particularly in regard to utility, simplicity, portability, automatability and trust/confidence.

Results

Comparison of Existing ICT Skill Frameworks: In this section, each of the three chosen ICT Skill Frameworks of SFIA, e-CF and SF for ICT are presented and then their salient features are compared in tabular form.

SFIA: SFIA is an ICT skill framework that has been developed incrementally over the past 20 years and is currently at version 6 with version 7 under development at the time of writing.

Version 6 defines 97 ‘professional’ skills in natural language which are for the most part equivalent to domain specific skills. For example, there are professional skills for Information security (SCTY), network planning (NTPL) and Programming/software development (PROG) where the four letter acronym in parentheses for each skill is known as a ‘skill code’. Some of the professional skills may also be regarded as domain independent to some extent, for example Sourcing (SORC). However, the 97 professional skills do not explicitly include traditional domain independent skills such as communication, leadership and teamwork.

As an example, the natural language skill definition for Information security (SCTY) is as follows: ‘The selection, design, justification, implementation and operation of controls and management strategies to maintain the security, confidentiality, integrity, availability, accountability and relevant compliance of information systems with legislation, regulation and relevant standards.’ (SFIA, 2018)

The 97 professional skills are classified into 6 categories as follows to aid in navigation of the framework:

- Strategy and Architecture
- Change and Transformation
- Development and Implementation
- Delivery and Operation
- Skills and Quality
- Relationships and Engagement.

For example, Information security (SCTY) belongs to the Strategy and Architecture category and Programming / software development (PROG) belongs to the Development and Implementation category.

In terms of proficiency for each skill, SFIA Version 6 specifies 7 'levels of responsibility' with associated names as illustrated in Figure 1. This demonstrates how increasing levels of responsibility are associated with increasing levels of leadership (a domain independent skill) since the names 'Enable' (level 4), 'Influence' (level 6) and 'Set Strategy, Inspire' (level 7) are all terms commonly associated with this skill as discussed in Leonard et al. (2013).

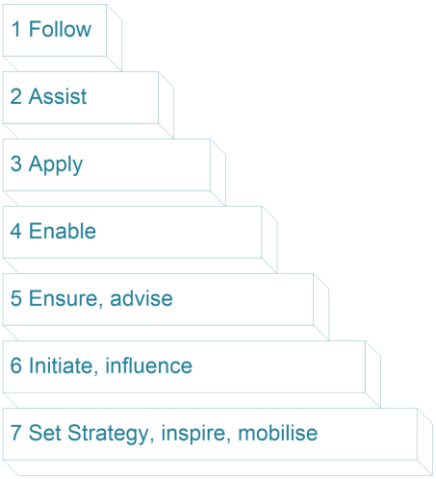

Figure 1: The 7 Levels of Responsibility in SFIA

Furthermore, each level of responsibility is defined in terms of the attributes of autonomy, influence, complexity and

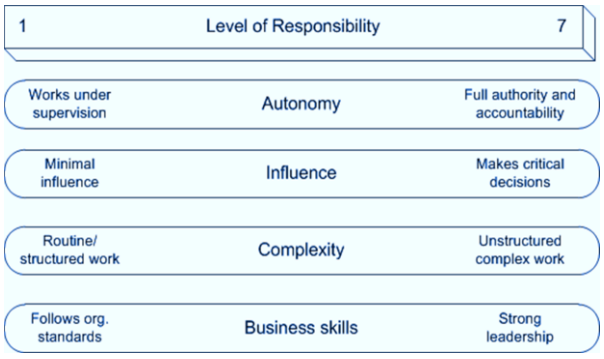

Figure 2: The 4 Attributes of Autonomy, Influence, Complexity and Business Skills in SFIA

business skills as demonstrated in Figure 2. The business skills attribute includes some aspects of domain independent skills such as communication and ethical decision-making.

In the SFIA skill framework, only certain contiguous levels of responsibility are applicable to each professional skill. This means a matrix is required which relates each professional skill to its applicable range of levels of responsibility. A subset of this matrix for professional skills belonging to the Strategy and Architecture category is illustrated in Figure 3.

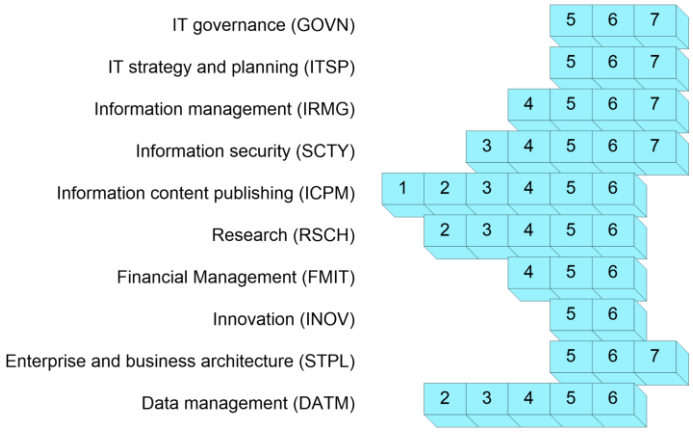

Figure 3: Sample Mapping of Professional Skills to Levels of Responsibility in SFIA

The SFIA skill framework does not specify unambiguous criteria to measure or certify the proficiency level of each skill for an individual. There are commercial organisations that offer skill assessment according to the SFIA skill framework, but they are presumably using proprietary assessment criteria that have not been agreed on an industry wide basis. As the SFIA skills and proficiencies are specified in natural language, there are no specific features to enable advanced automation e.g. an ontological approach as discussed by Lundqvist et al. (2008). As discussed earlier, an example of advanced automation in skills management is parsing a Request for Proposal (RFP) and distilling the skills and associated proficiencies needed to support it without human intervention.

e-CF: e-CF is an ICT skill framework that began life in the mid-2000s supported by the European Commission and is currently at v3.0. It is also published as European standard EN 16234-1 (CEN, 2016).

The current version defines 40 'competences' in natural language which can be regarded as equivalent to domain specific skills. For example, there are competences for Information Security Strategy Development (D.1.), Solution Deployment (B.4.) and Application Development (B.1.) where the code in parentheses for each competency is based on a categorisation of competences into letter

groups that is discussed in the next paragraph. Some of the competences may also be regarded as domain independent skills to some extent, for example Purchasing (D.4.). However, similar to SFIA, the 40 competences do not explicitly include traditional domain independent skills such as communication, leadership and teamwork.
The 40 competences are classified into 5 categories or areas with associated letter groups as follows based upon the ICT lifecycle:

A. Plan
B. Build
C. Run
D. Enable
E. Manage

Based upon this classification, it seems reasonably logical that the competences Solution Deployment and Application Development belong in the Build category while Information Security Strategy Development and Purchasing belong in the Enable category. The 5 categories are sometimes referred to as 'Dimension 1' and the 40 competences as 'Dimension 2' of the framework.

With respect to proficiency for each competency, which is sometimes referred to as 'Dimension 3' of the framework, e-CF specifies 5 'proficiency levels': e-1 (basic proficiency) through e-5 (high proficiency). Similar to SFIA, these proficiency levels are associated with increasing levels of leadership (a domain independent skill). Furthermore, and again with some similarity to SFIA, each proficiency level is defined in terms of the attributes of autonomy, complexity and behaviour as demonstrated in Figure 4. Domain independent skills other than leadership do not appear prominently in the framework, but they are implied in some of the descriptions both of competences and proficiency levels.

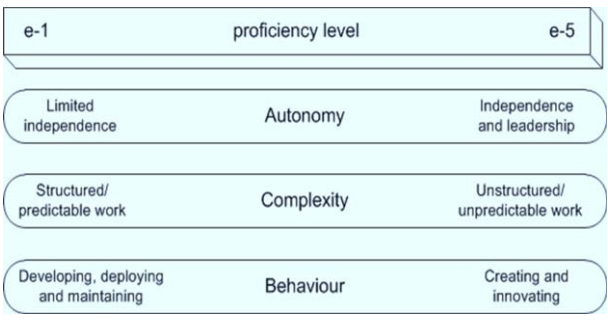

Figure 4: The 3 Attributes of Autonomy, Complexity and Behaviour in e-CF

There is also a 'Dimension 4' of e-CF which provides examples of knowledge and skills related to the competences in Dimension 2. These are purely informative to help explain the framework and are not intended to be exhaustive.

As in the SFIA skill framework, only certain contiguous proficiency levels are applicable to each competency. This again means a matrix is required which relates each competency to its applicable range of proficiency levels. A subset of this matrix for competences belonging to the Plan and Build categories is illustrated in Figure 5.

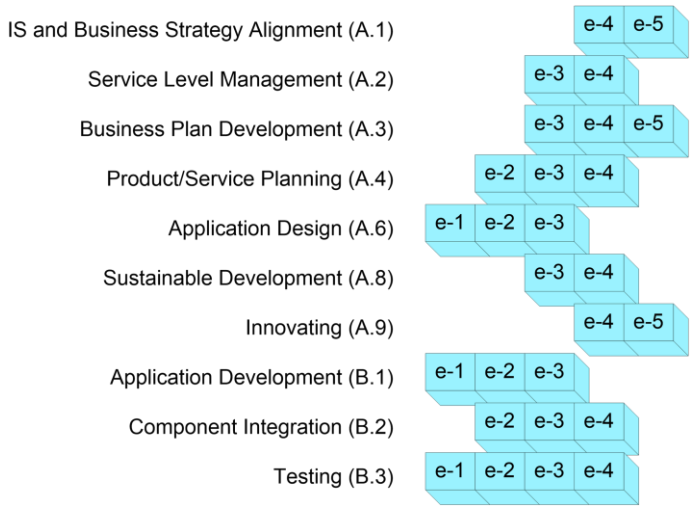

Figure 5: Sample Mapping of Competencies to Levels of Proficiency in e-CF

e-CF also does not specify unambiguous criteria to measure or certify the proficiency level of each competency for an individual, and there are no specific features to facilitate advanced automation.

SF for ICT: SF for ICT is a new initiative (launched in 2017) of SkillsFuture Singapore (SSG) and others, including industry, to develop an ICT skill framework for Singapore. It defines 119 ICT job roles, such as Security Engineer, Infrastructure Engineer and Applications Developer. Each job role is dissected into a number of building blocks in terms of 'Technical Skills and Competences' (TSCs), which correspond to domain specific skills, and 'Generic Skills and Competences' (GSCs), which correspond to domain independent skills, both of which are specified in natural language. For example, for an Application Developer, the TSCs include Application Development and Business Needs Analysis, while the GSCs include Teamwork and Communication. This is quite different to the SFIA and e-CF ICT skill frameworks for which job roles are outside the framework scope and only base skills (which mostly correspond to domain specific skills) are specified.

However, it is very closely aligned conceptually to how many job roles and position roles are developed in terms of the separation between domain specific and domain independent skills.

In all, the 119 job roles are based upon 80 TSCs and 18 GSCs. The TSCs are classified into 7 categories as follows:

- Design
- Development and Implementation
- Operations and User Support
- Project Management
- Sales and Marketing
- Stakeholder and Contract Management
- Strategy and Architecture

In terms of proficiency for each skill, TSCs have 6 numbered proficiency levels (with 1 being the least proficient and 6 being the most proficient) and GSCs have proficiency levels of 'Basic', 'Intermediate' and 'Advanced'. Unlike SFIA and e-CF, the numbered proficiency levels for TSCs are not associated with increasing levels of leadership; this is primarily because leadership is represented separately as a GSC. However, similar to SFIA and e-CF, the numbered proficiency levels for TSCs are defined in terms of the attributes of responsibility, autonomy, complexity and knowledge/abilities as demonstrated in Figure 6.

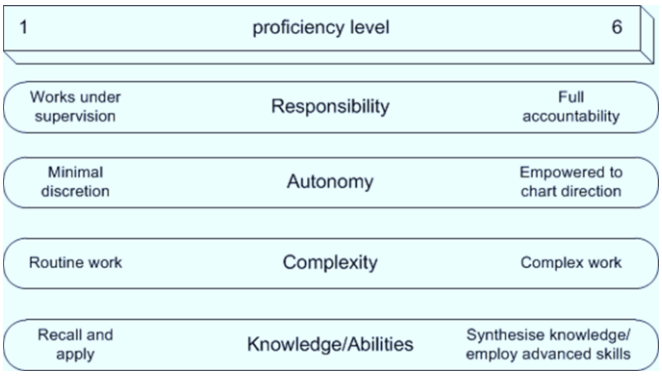

Figure 6: The 4 Attributes of Responsibility, Autonomy, Complexity and Knowledge/Abilities in SF for ICT

Also with similarity to the SFIA and e-CF skill frameworks, only certain contiguous proficiency levels are applicable to each TSC, so this means a matrix is required which relates each TSC to its applicable range of proficiency levels. A subset of this matrix for TSCs belonging to the Strategy and Architecture, and Development and Implementation categories is illustrated in Figure 7. The GSC proficiency levels of 'Basic', 'Intermediate' and 'Advanced' are applicable to all 18 GSCs.

SF for ICT also does not specify unambiguous criteria to measure or certify the proficiency level of each TSC or GSC for an individual, and there are no specific features to facilitate advanced automation.

Figure 7: Sample Mapping of TSCs to Proficiency Levels in SF for ICT

Summary of Skill Frameworks: Table 1 summarises the salient characteristics of the three existing ICT skill frameworks previously discussed. The frameworks exhibit some striking similarities, for example in the definition of attributes for proficiency levels. This should not necessarily be taken as a validation of these aspects of the frameworks because the frameworks were not necessarily developed independently given they were initiated at different times. In particular, SFIA predates e-CF, which in turn predates SF for ICT, so SFIA was a reference for both other frameworks during their development. Had the frameworks been developed in isolation of each other, it is possible they would have exhibited less similarity.

Conversely, the frameworks exhibit some striking differences, in particular in terms of the number of domain specific skills specified and the fact that only SF for ICT explicitly caters for domain independent skills such as communication, leadership and teamwork. SFIA and e-CF do incorporate the concept of domain independent skills, and particularly leadership, to some extent in terms of proficiency levels.

It is also evident that there are some features which might be expected to be included which are missing from all three existing ICT skill frameworks. In particular, none of the frameworks specify unambiguous criteria to measure or certify the proficiency level of each skill for an individual

	SFIA	e-CF	SF for ICT
Number of domain specific skills	97	40	80
Name of domain specific skills	Professional Skills	Competencies	TSCs
Number of categories of domain specific skills	6	5	7
Number of domain independent skills	0	0	18
Name of domain independent skills	N/A	N/A	GSCs
Number of proficiency levels for domain specific skills	7	5	6
Name of proficiency levels for domain specific skills	Levels of Responsibility	Proficiency Level	Proficiency Level
Number of proficiency levels for domain independent skills	N/A	N/A	3
Name of proficiency levels for domain independent skills	N/A	N/A	Proficiency Level
Attributes for proficiency levels associated with domain specific skills	Autonomy Influence Complexity Business Skills	Autonomy Complexity Behaviour	Responsibility Autonomy Complexity Knowledge and Abilities
Job roles defined	No	No	119
Certification criteria for individuals	No	No	No
Automation features	No	No	No

Table 1: Comparison of Existing ICT Skill Frameworks

which makes any assessment of skills subjective and therefore of questionable value. In addition, none of the frameworks specify features to enable advanced automation e.g. an ontological approach as discussed by Lundqvist et al. (2008).

Discussion: This section discusses the implications of the previous comparison between the existing ICT skill frameworks, particularly where there are significant differences between the frameworks or where there are apparent conflicts with objectives or user expectations.

Number of Domain Specific Skills: It is clear that the existing ICT frameworks employ a significantly different number of domain specific skills, ranging from 40 for e-CF to 97 for SFIA. While it may be argued that SFIA has a wider overall scope then e-CF, this does not account for the magnitude of the difference and it seems clear that e-CF domain specific skills are broader in scope in general than SFIA domain specific skills. While the choice of the number of domain specific skills is somewhat subjective, it is perturbing that such a difference exists between e-CF and SFIA in this respect. This, for example, complicates mapping or translating skills between the frameworks which is related to the end user expectation of portability.

Treatment of Domain Independent Skills: Of the three ICT skill frameworks surveyed, only the SF for ICT skill framework explicitly caters for domain independent skills such as communication, leadership and teamwork by virtue of 18 GSCs. SFIA and e-CF incorporate these skills, and in particular, leadership, in the proficiency levels of domain specific skills. However, this creates a predicament, because the proficiency of domain specific skills is part dictated by strict technical competence in that domain, and part by leadership and other domain independent skills as shown in Figure 8. The division between the two is not clearly defined in either SFIA or e-CF.

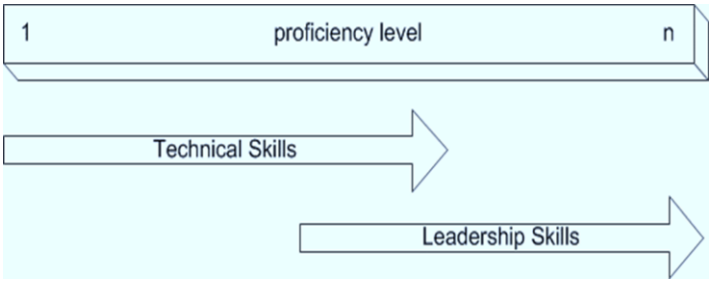

Figure 8: The Joint Role of Technical and Leadership Skills in Proficiency in SFIA and e-CF

From a practical perspective, this is troubling and appears to go against the end user expectation of utility. Imagine a scenario with a technical expert in a particular domain who has no leadership competence/experience and his/her supervising manager/leader who has no technical competence/experience in that domain. According to SFIA and e-CF, the expert is regarded as having a mid-level proficiency in that domain, yet the manager/leader *might* be regarded as having the highest level of proficiency in that domain because they have leadership skills. This seems counter intuitive. Compare this with SF for ICT, where the technical expert is regarded as having the highest level of proficiency in the specific domain TSC and no proficiency in the leadership GSC, and the manager/leader is regarded as having no proficiency in the specific domain TSC and the highest level of proficiency in the leadership GSC.

Use of Attributes: All three ICT skill frameworks surveyed employ attributes for proficiency levels associated with domain specific skills (see Figures 2, 4 and 6). In fact the attributes of 'autonomy' and 'complexity' are common to all three frameworks, although the definitions vary somewhat. There is a question whether these attributes contribute any useful function to the framework, and further, whether they actually reduce the usefulness of the framework. Consider the attribute complexity for instance. Is it always true that an individual who is least proficient in a skill works in a routine/structured capacity and one that is most proficient works in a complex/unstructured capacity? It may be true in some or even the majority of cases, but unless it is always true, how does it contribute usefully to the framework? Consider an entry-level technician who is required to troubleshoot network issues; some of these might be incredibly subtle and complex to solve, requiring initiative and problem solving skills. On the other hand, a manager/leader often has the power to delegate complexity so that they do not need to address it personally. The same or similar arguments may be applied to the attribute autonomy and other attributes.

More generally, the concept that as skill proficiency increases, each of the attributes autonomy, complexity etc. must monotonically increase too seems quite inflexible and limiting. There is an argument that proficiency should be defined as a single metric, not as a collection of independent attributes which are forced to vary in concert with each other as proficiency increases. The use of attributes appears to go against the end user expectations of utility and simplicity, and possibly even trust/confidence.

Complexity of Skill / Proficiency Mapping: With all three ICT skill frameworks surveyed, only certain contiguous proficiency levels are applicable to each domain specific skill (see Figures 3, 5 and 7). Furthermore, usually there is no explicit explanation for why certain proficiency levels are excluded. This might be regarded as overly complex and go

against the end user expectations of simplicity. It should be possible to define the proficiency of any skill with the same number of levels. Even when considering skills that require a great deal of leadership (e.g. IT Governance or IT Strategy) and therefore which only currently exist at the highest levels of proficiency at least in SFIA and e-CF, it can be argued that a basic level of proficiency should be defined for entry level positions.

Lack of Certification Criteria: None of the three ICT skill frameworks surveyed include criteria which allow an individual to unambiguously and universally certify their skills at certain proficiency levels. This might be by design as implied by the term 'framework'. However, not including such criteria limits the portability of the framework between organisations and ultimately limits the usefulness of the framework. In other words, it appears to go against the end user expectations of utility and portability.

By way of analogy, when technical specifications or standards are developed, they usually can be interpreted differently by different parties no matter how much effort is placed on language clarity in the documents. For this reason, test specifications are developed which facilitate unambiguous and universal certification of implementations of the specification/standard.

The same principle can be applied to ICT skill frameworks. Two different organisations may interpret the exact requirements for an individual to satisfy a given skill at a given proficiency differently. This may not be a huge issue within the scope of one such organisation, but for goals of the framework such as certifying that external candidates for jobs satisfy certain skill requirements, the ambiguity limits the usefulness of the framework. In fact, it can be argued that self assessment of skills and proficiencies is a valid proposition in this environment. This can be mitigated by defining unambiguous and universal certification criteria.

One aspect of such ICT skill framework certification is to map existing industry certifications (e.g. CCNA for networking, PRINCE2 for project management) and qualifications to the framework. While industry certifications and qualifications should not be the only route to skill framework certification, they are an important aspect as such certifications/qualifications are very popular. In fact, some attempt to map industry certifications to SFIA has taken place (SFIA, 2018), although this initiative is fragmented and incomplete at best.

Lack of Automation Features: None of the three ICT skill frameworks surveyed include explicit automation features partly on account of the fact that the skill and proficiency definitions are specified solely in natural language. As detailed by Lundqvist et al. (2008), there are methods of structuring the skill and proficiency definitions to make them more amenable to automation based upon syntax and semantics. This facilitates advanced automation e.g. parsing a Request for Proposal (RFP) and distilling the skills and associated proficiencies needed to support it without manual intervention.

Conclusion: There are clearly significant differences between the existing ICT skill frameworks of SFIA, e-CF and SF for ICT in terms of the number of domain specific skills and the method of representing domain independent skills. Furthermore, all the frameworks can be viewed as being somewhat complex in terms of their use of multiple attributes to define proficiency and the intricate and largely unexplained way in which skills are mapped to permissible proficiency levels. This implies that debate is still required about how an ICT skill framework should be designed to be of maximum use. Furthermore, the lack of unambiguous and universal certification criteria is an inhibiting factor to the more wide scale use of such frameworks because it limits their portability between organisations. In the absence of true portability in the context of a single framework, translating or mapping skills between the various frameworks is not a useful exercise. Finally, the lack of explicit automation features in the frameworks also limits their usefulness for advanced use cases in skill management. The end user goals of utility, simplicity, portability, automatability and trust/confidence are not completely satisfied by any of the existing ICT frameworks.

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