

Cyber Forensics Competency-Based Framework - A review

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ABSTRACT

Lack of Cyber Forensics experts is a huge challenge facing the world today. It comes due to the fancy of Cyber Forensics training or education. The multidisciplinary nature of Cyber Forensics proliferates to diverse training programmes, from a handful day's workshop to Postgraduate in Cyber Forensics. Consequently, this paper concentrates on analyzing the Cyber Forensics training programmes in terms of Competency-Based Framework. The study proves that Cyber Forensics training or education has improper Competency-Based Framework.

KEYWORDS

Cyber Forensics, Cyber crimes, Knowledge, Skills, and Ability, Competency Identification, Competency Standardization, Competency-Based Training, Competency-Based Assessment Certification, Quality Assurance and Accreditation, Competent

1. INTRODUCTION

Nowadays, Information and Communications Technology (ICT) has great impact to our life, mostly in a positive way [1]. It forms many aspects of our modern lives and most activities of the people around the world. ICT obviously exists on communication system, transportation, food production, factories, entertainment, etc. In addition, the rapid progression and development

of computers, networks and communications and others boost the ICT domination.

In contrast these technologies also contribute in some crimes events. In other words, they engage on massive Cyber crimes [2]. So, it is hard to find a crime that doesn't potentially involve digital evidence. Researchers [3] estimate of over 85% of criminal and civil prosecution cases have got digital evidence. These crimes are such as fraud, hacking identity theft and other illegal activities.

Consequently, Cyber crimes have a substantial impact on the world economies. Researches carried out in USA and UK companies indicate that the financial losses as a result of Cyber crimes are very high [4], [5]. Therefore, several businesses have lost reputation, while, individual privacy and even public safety exposed to risks. Furthermore, national security concerns have also risen. Securing information technology assets of organizations also becomes more complex and highly recommended.

Cyber Forensics (CF) mission is to fight crimes committed by computer utilities either as a source of crime, storage for or for facilitating criminal activities.

Z. Hamzah [6] defines CF as "legal aspects of computer investigation and involves the analysis of digital evidence covering the identification, examination, preservation and presentment of

potential electronic evidence in a manner that would allow such evidence to be admitted in a court of law”.

Therefore, CF has a great contribution on computer and network security, information assurance, law enforcement, and national defense [7]. For instance, qualified CF first responders are most required in National Critical Corporations. The importance of CF comes due to the needs of both service availability and keeping the system compromise evidence [8]. Thus, the jobs of the CF Investigators are not only collecting and analyzing, but are also present the evidence in the court properly. So, the CF Investigators should be qualified in order to integrate knowledge, skills, and abilities in the identification, preservation, documentation, examination, analysis, interpretation, reporting and testimonial support of digital evidence [9].

In spite of the fact that the CF origin goes back to early 1980s, and new training or education qualifications are run regularly in some countries, researchers have found that many countries around the world lack CF Investigators [10], [11], [12]. The lack of professionalism in CF comes as a result of some factors. For instances, the shift towards digital evidence for both criminal and civil cases creates high demand for digital forensics specialist by military, law enforcement and private industry [13]. Training and education services of CF are relatively new. Furthermore, many of the qualifications are presented by vendors and owners of CF tools. In addition, most of training or education providers concentrate on the system weakness or training trainees on the use of specific tools or techniques, rather than focusing on knowledge, skills, ability (KSA) and competency-

based needs [14]. Finally, most of qualifications and programmes are not verified by independent external examiners or accreditation bodies [15, 16].

In this paper, the authors review the current situation of the of CF education and training practices in both academic and non-academic institutions, in terms of Competency-Based framework prospective.

The investigation sited CF related programmes including two-year associate degrees and diplomas [30], [31], four-year undergraduate programmes [22], [30], [31], [32], [33], [34], [35], [36], [37], [38], [39], [40], [41], [42] postgraduate degree programmes [30], [43], [44], and professional certification programmes [30], [35], [31], [45], [46], [47], [48].

The paper is structured as follows. This section introduces the problem behind this study. Section two presents a critical analysis concerning training competency-based framework in academic and non-academic programmes. Section three is a brief discussion, while, section four summarizes the study.

2. COMPETENCY-BASED FRAMEWORK

2.1 Competency Identification (CI)

A competency is defined as “comprehensive ability of a person that allows him to have an efficient performance in specific labor situations” [17]. While, an institution of human resources training and development such as the Australian National Training Authority defines competency as ability to do jobs and duties according to specific job’s standards [17].

Competency “is much more than just a description of a work task or activity. It encompasses measures of the competency and addresses the knowledge, skills and attitudes required for a person to perform a job to a required standard” [18]. Competency is verified by the ability to apply KSA, where is relevant and defines the personal attributes [19]. Labor Competency is not the likelihood to achieve the work; it is realizing abilities demonstration.

The CI is a process of establishing the competencies from the basis of labor activities [17]. Nowadays, various CI methodologies have been proved such as occupational analysis, functional analysis, develop of curriculum (DACUM), a model (AMOD) and systematic curriculum and instructional development (SCID) [17].

The CI is identified by subject matter experts from different institutions (private and public). For instances, groups of workers experts to define the workplace needs, state representative members of the executive and legislative power, digital forensics professionals, laws and juries representatives, and scientific and intellectual professionals from training and educational institutions.

Literature review shows various CI on CF training programmes. According to P. Craiger [20] subject matter expert from academia, the private industry and government developed a model for competencies. While, a curriculum development committee of Computer Information System defined competencies through analyzed the recent computer forensics practices as well as the information collected from neighboring police department [21]. Moreover, Yasinsac A. et al [22] defined

four forensic job positions as references to develop a CF curriculum.

2.2 Competencies Standardization (CS)

The CS is carried after competencies have been identified. It is a process of common procedure description that clears up the dealing between workers, employers and educational providers. As well as, it is a reference to the workers, employers and educational providers [17]. Standardization is the key that is shared by all actors in the training fields. Individual CS includes the achievement capabilities, the way of performance judgment, circumstance, the types of performance evidence collection, quality maintaining, problem solving capabilities and support others colleagues.

Although CS is carried on earlier in most of the others training and education services, some researchers claim that there is absence of CF professional certification standardization [23], [24], [25], [26].

2.3 Competency-Based Assessment and Certification (CBAC)

Certification proves formal recognition of the identified competencies, through comprehensive individual competencies assessment against the standard. Competency Based-Assessment (CBA) is defined by ILO [17] as the process of collecting evidence about the employee’s occupational performance; in order to form judgments on his proficiency with respect to standards identifies the areas of required performance. It offers a transparency on the standardized certification system that allows workers to know the expectations from them, employers to maintain the

required competencies and training providers to build curriculum.

The characteristics of competencies certifications are [17]:

- It is done within a consistent occupational framework
- It requires a framework of legitimacy, credibility, transparency and appraisal
- It is carried out with a simple mechanism.

Certification is done based on the assessment of the individual competencies such as assessing the product evidence that is done by the trainee in actual activities, through the use of simulation in some activities, observing the trainee while skillfully performing his job, oral or written question to test his knowledge, etc. [27], [28]. However, the CBA totally differs from traditional assessment [17], as in Table. 1.

Table 1. Traditional assessment systems Vs competency based assessment

Traditional assessment systems	Competency based assessment
Parts or programs are assessed by final examination	Gathering and judgment of evidence with objectives.
Success or fail are defined by marking scores	The decision is (competent or not yet competent).
It is done in limited time	It is not subject to predetermine time

An effective CBA is required to be initiated within the training or education primary objectives in order to guarantee the trainees' proficiency. The CBA idea is based on trainees being *competent or not yet competent*. It is stating that there is sufficient evidence to show the trainee is competent or not [17], [29]. In addition, it must be carried continuously during the training or education process

in order to remedy the trainee's competency deficiency earlier.

2.3.1 Associate Degrees and Diplomas Programmes (ADDPs)

In order to meet court rules for evidence admissibility, all of (ADDPs) offer training on how to set up CF procedures properly, and how trainees use commercial CF software packages in standard methods and continuous process; as well as the followings:-

- To identify and secure the Cyber evidence at crime scenes.
- To record all procedures carried out at crime scenes and sources of Cyber evidence.
- To maintain the evidence handling and chain of custody properly.
- To ensure valid forensic images are taken to original Cyber device
- To use a virtual environment to boot or restore the image of forensic evidence
- To save the multiple copies of potential evidence on in a different digital media

The CF is known as laboratory procedures that depend on many steps. So, variety of hands-on laboratory exercises is provided. In addition, some of CBA methods are used to ensure the trainees' proficiency, such as programme documentation, objectives evaluation and regular assessments to determine whether the programme objectives and the development needs are met or not [30, 31], see Table 2.

Table 2. ADDPs Trainee Competency Assessment

CBT Methods	Assessment	Stated	Not stated
Examination		-	2
Assignment		-	2
Observation		-	2

Product evidence	-	2
Witness testimony	-	2
Simulation	-	2
Others	2	-

Table 2 above shows ADDPs trainees' competency. As seen, most of competency assessment methods are not shown totally, except programme documentation and objectives evaluation.

2.3.2 CF Undergraduate Programs

A conspicuous similarity of Undergraduate's degree programmes in both training and CBA methods are shown in Table 2. They deliver subjects as a combination of lectures and Laboratory sessions. The hands-on exercises take a major position on training delivery, as well as some types of assessment. Computer Science degree at the University of Western Sydney [10] depends on assignments and exams to evaluate its trainees. While, lab exercise log books and written report are used by faculty for student assessment [32], [33]. The Undergraduate computer forensics program that is part of the Computer Information Systems (CIS) uses three quizzes, midterm exam, and final exam to assess the trainees. Deakin University in Australia adopts two simulated assignments to develop the trainees' skills. Each assignment is case study [34].

Table 3. Undergraduate Trainees' Competency Assessment

Concepts	Stated	Not stated
Examination	3	12
Assignment	4	11
Observation	-	15
Product evidence	-	15
Witness testimony	-	15
Simulation	2	13
Others	3	12

Table 3 depicts CF Undergraduate programmes' competency assessment methods. The study shows noticeable likeness of undergraduate's degree programs trainees' assessment methods. All of them show implementation of insufficient competency assessment methods. From Fifteen Undergraduate programmes studied, nine of them [22], [30], [35], [31], [36], [37], [38], [39], [40] don't mention trainee's competency evaluation. One programme [41] shows 14.3% of CBA methods implementation. Four programmes [32], [33], [34], [42] implement 28.6% of CBA methods, and only one program gears over 40% of assessment methods.

2.3.3 CF Postgraduate Programs

Most of Postgraduate CF training or education programmes are at Master of Science (M. S.) level. A Postgraduate or Master-level on CF training or education programmes intends to do more than educating trainees in theoretical concepts. They equip the trainees with abilities and skills techniques of how to think critically, solving problem, and adequate knowledge with the forensic science discipline [30]. The CF programmes are multidisciplinary mix of ethical, legal, technical and Courtroom testimony-based course. Hands-on knowledge is the main laboratory component. Researches, conferences, assignments and simulated courtroom are used to assess the trainees' competency, see Table 4.

Table 4. Postgraduate Trainees' Competency Assessment

Concepts	Stated	Not stated
Examination	-	3
Assignment	1	2

Observation	-	3
Product evidence	-	3
Witness testimony	-	3
Simulation	1	2
Others	3	-

CF Postgraduate and diploma programmes CBA methods are shown on Table 4 above. Of the three Master programmes studied, the trainee's CBA percentages are below 50%. Two programmes [30], [43] provide 14.3% of CBA methods. They only use research and conferences to measure their student's competency levels. [44] Shows 42.8% of CBA methods are implemented such as assignments, simulation and research.

2.3.4 Professional Certification Programs (PCPs)

Although the (PCPs) are qualifications that can be received from academic institutions, they are mainly obtained from professional institutions. For instance, some software vendors offer forensics skill training via some courses, such as Encase software training [3], [45], for more details, see Table 5.

Table 5. Professional Computer forensics certifications

Certifications	Training or education providers
Certified Hacking Forensics Investigation (CHFI)	EC-Council
Certified Computer Examiner (CCE)	Int'l Society of Forensics Computer Examiners
GIAC Certified Forensics Analyst (GIAC CFA)	Global Information Assurance Organization
Certified Computer Crime Investigator (CCCI)	High Tech Crime Network
Certified Forensic Computer Examiner	Int'l Association of Computer

(CFCE)	Investigators
Cyber Security Forensics Analyst (CSFA)	Cyber Security Institute

Though the PCPs don't grantee trainees competencies, they establish a knowledge baseline. They provide Computer forensics practicing that shows some skills of individuals. [30] States that "Certificates in digital forensics alone may not be sufficient for an entry level position in digital forensics". Examination, assignment, observation, Peer- review publications and Instructor of presenter evaluation are carried out to assess the trainees' competency as shown in Table 6 below.

Table 6. Professional Certification Programs Trainees' Competency Assessment

Concepts	Stated	Not stated
Examination	2	4
Assignment	1	5
Observation	1	5
Product evidence	-	6
Witness testimony	-	6
Simulation	-	6
Others	1	5

The authors site 6 Professional Certification Programmes [30], [31], [35], [45], [46], [47]. Table 6 shows insufficient trainees' CBA implementations. Four out of six programmes don't reveal their trainee evaluation system methods [31], [35], [46], [47]. [38] Uses only written exam methods to assess the trainee. Whereas, [30] uses examination, assignment, observation and peer review publication in the trainee's evaluation system.

2.4 Competency-Based Training (CBT)

The CBT depends on appropriate training curriculum, that competency standards are obviously essential.

Moreover, training curriculum program that is geared from standard is more efficient and totally reflect comprehensive job needs [17]. Curriculum design should identify required competencies that need to be developed, knowledge be applied, skills and personal attitudes. It is usually structured in modules that form units of competencies.

Moreover, the unit of competencies presents the workers' need to know in order to from the theoretical knowledge, how to perform and be acting in order to meet the required attitudes. The methodology uses to develop a curriculum design covers the following:-

- Analysis of a vocational qualification.
- Definition of the training modules.
- Definition of the curriculum units that formed from modules.
- Definition of the educational objectives, assessment criteria, training contents, educational methodologies teaching resources, educational environments, equipment, machines, tools and timetables.
- Development course plan
- Quality control.

2.5 Quality Assurance And Accreditation (QAA)

Quality Assurance (QA) is a process of assessing quality through both planned and orderly actions in order to show a product/service confidence or specific requirements for quality are met on the service offered [19]. Thus, the Quality assurance systems would minimize the risks inherent in training providers by maintaining the quality of teaching/training and assessment methods carried on training providers.

W. Pond [48] states Accreditation as “the procedure by which an authoritative body gives formal recognition that a body or person is competent to carry out specific tasks”.

Accreditation is a header of the quality assurance program that monitors the efforts of management practices, personnel performance, internal and external quality system and procedures exerted to meet national and/or international standards [19]. Accreditation has many benefits, including:-

- Validation and external value assurance.
- Encourages students/trainees to select a program.
- Proves the quality of the program.

3. DISCUSSION

CF professionalism varies from first responders to analysts and experts. However, we are not surprised to find significant divergences in competencies identification, standardization, competencies assessment methods and certification, competency-based training, and quality assurance and accreditation. Firstly, Competencies Identification: literature reviews demonstrated the lack of adequate competencies identification practices in most of CF training programs. However, the integration of the researchers [20], [21], [22] findings together meet the competencies identification procedures as defined earlier.

Secondly, Competencies Standardization: It is recognized that the diversity in CF training programmes objectives and competencies identification throughout the world creates a huge consensus gap. Thirdly, Competency Based-Assessment (CBA): Overall, the implementations of

the CBA methods of CF training or education programmes are below 50%.

Fourthly, Competency-Based Training: Generating a standardized training curriculum however is a difficult assignment due to inadequate competencies identification, absence of standardization and inconvenient competency-based assessment.

Fifthly, Quality Assurance and Accreditation: According to Elfadil S. et al. [16] there are similarities on the ADDP quality internal verification and accreditation. They are totally not shown in the whole programs. In addition to that, only one of four organizations (25%) confirmed its accreditation expectation. Certificate Programs show only 12.5% internal verification and accreditation. The result of the analysis on Undergraduate Programs shows 5% external verification, 5% internal verification and 25% accreditation. Finally, Master/Graduate diploma shows 10% to internal verifier, 10% external verifier, and 40% to accreditation (16)

4. CONCLUSION

In summary, Cyber Forensics training or education services proliferate to diverse qualifications, from a handful day's workshop to Masters Degree in Cyber Forensics. With the immaturity of education or training and practicing programs, most of the training or education providers don't worry about training Competency-Based framework. This contributes to poor services delivery and outcomes. The study shows inadequacies of competencies identification process, standardization, trainees' Competency Based-Assessment methods, in addition to Competency-Based Training curriculum, and Quality Assurance and Accreditation. Overall,

the result shows the area of Cyber Forensics training or education need competency-based framework.

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