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Abstract: Ensuring students are equipped with the necessary skillsets for the workplace has become a priority for Higher Education Institutions (HEIs). This is especially true in the ever changing field of network security. Competency frameworks can contribute towards the creation of relevant curricula. Various approaches to delivering such education exist. Blended learning, one of the most popular approaches, has shown promising results yet there are still many factors that plague the successful adoption and implementation of e-learning programs at HEIs. This paper investigates how the Cisco Networking Academy Program (CNAP) has integrated blended learning effectively to prepare graduates for network security positions while adhering to global competency standard needs.

Keywords: Blended learning, Cybersecurity, Competency, CNAP, Higher Education

1. Introduction

Information Communication Technology (ICT) has assumed a critical role in facilitating social-economic development in many countries. According to ENISA [1], ICT solutions such as communication networks and information systems are necessary for economic and social development and are fast becoming universal utilities, much like water and electricity. Due to the strong reliance on information, the protection of information resources has become of critical importance to many organizations, both in developed and developing countries. Already more than 50 nations have published their official stance on cybersecurity [2]. Cybersecurity related fields such as information security and communication network have been placed as a leading priority by ICT managers [3]. More and more graduates are seeking for employment in cybersecurity related jobs, yet there is still a lack of an adequate cybersecurity workforce. Not only is there a shortfall of a skilled cybersecurity workforce which is a critical vulnerability for companies and nations, but there is also little consistency in terms of how cybersecurity work is defined or described.

This absence of a common language to describe and understand cybersecurity work hinders the establishment of a consistent baseline of capabilities, the identification of skills gaps and the assurance of a steady pipeline of future talent. Hence many organizations and countries have adopted competency frameworks as an industry wide approach to describing competencies in cybersecurity [4]. These competencies are based on industry standards and can be learned and assessed through competency-centered learning programs. One of the most widely accepted and administered competency-centered learning program at HEI is the Cisco Networking Academy Program (CNAP) [5]. The CNAP encompasses communication networks as a whole, as it seeks to prepare graduates for competency intense job positions and for industry certifications [6]. The program also consists of a dedicated network security course. The network security course program is industry recognized and is currently being implemented at many HEI. Even with the wide spread popularity of e-learning platforms such as blended learning at universities, there are many challenges that still plague the large scale integration of these competency-centered learning programs at HEI. This is more apparent in countries where there is little to no ICT infrastructure for education. Most e-learning initiatives in developing countries have not been successful [7,8,9], this is largely due to fact that developing countries are mimicking the e-learning trends of developed countries with the expectations of reaping the same benefits enjoyed by HEI in developed countries [7,9].

Furthermore, cybersecurity needs and expectation for developing countries are different from cybersecurity needs in developed countries [10]. Even with these obstacles the CNAP program has been able to effectively integrate Blended learning to prepare graduates from all around the world for cybersecurity related positions while adhering to global industry competency needs. The Objective of this paper is to evaluate the effectiveness of CNAP as a network security curriculum in HEIs, by evaluating it against cybersecurity competency framework and well-known blended learning best practices.

2. Competency in Cybersecurity

It is generally accepted that to be regarded as proficient at a profession; one has to have significant knowledge and skill in a particular domain or discipline, have been accepted by the community, either through certification or general recognition as one who is qualified to practice in that discipline, operates with authority and responsibility, and be of service to the community [11]. But does this abstract view of professionalism apply to cybersecurity? The individuals who are at the forefront of protecting information resources are known as cybersecurity professionals. However, little is known about the work practices of these professionals. In reality, the cybersecurity industry is much more complex. [12]. Note that job titles vary considerably across organizations, and there is a lack of functional job descriptions of cybersecurity related professions, such as network security professionals. Furthermore, studies have shown that even ICT professions that do

not have the word “security” in their job titles also spend a considerable amount of time performing security-related activities on a daily basis [13].

To address the lack of a common description for cybersecurity work, competency frameworks are used by organizations to account for cybersecurity competencies. Competency frameworks consist of a classification of the attributes required to be competent at a profession. In general competency is an individual’s ability to draw on the knowledge, skill and attitude (KSA), necessary for performing activities to a specified standard. This standard is referred to as competency standard [14]. Competency standards can be described as an industry-determined specification of performance which sets out the KSA required to operate effectively in a job role [15].

HEIs are the primary source of initial education and training for cybersecurity professionals [49]. Such institutions play a role in shaping the public perceptions of a profession through provisioning of educational programs that prepare students for a chosen profession. In reality there is a short supply of ICT skills and it cannot keep pace with the growing demand [3]. While much promotion for ICT related degrees use career outcome to market potential students, for many of these degrees there’s little evidence whether these outcomes are truly embedded into the curriculum [16]. With growing pressure from industry, HEIs are required to perform a series of actions that can improve the current situation. This suggests that ICT courses should focus on building the skills and competencies that lead students to successful employment, rather than just traditional university objectives, which are aimed at teaching students the general skills of problem solving and how to find and transform knowledge to useful information. Oliver [17] further states that curricula are now favoring competency and performance, “Curricula are starting to emphasize capabilities and to be concerned more with how the information will be used than with what the information is”. Competency frameworks and competency standards are now being mapped to HEI curriculum, but narrowing the gap between industry and HEI requires more than a tick-the-box approach, embedding professional skills and competencies into the curriculum should be done as part of a holistic educational design. Thus the new challenge faced by HEIs is articulating and developing employability skills that are still sustainable, pedagogically sound, and of high quality.

3. Cisco Networking Academy Program (CNAP)

The Cisco Networking Academy Program (CNAP) is a global competency-centered, on-line educational program, delivered through a Blended Learning approach. The program seeks to educate and train students, so they can design, troubleshoot and secure communication networks [5]. The CNAP program’s curriculum is industry competence-centered and is congruent with industry certifications [18]. Cisco Systems first officially launched the CNAP program in 1997, when they observed that many HEIs lack adequate network competencies. They began partnering with institutions from all around the world, to date more than 16 500 Institutions from over 165 countries have enrolled in

Networking Academy courses since its initial start [19, 6] CNAP is able to leverage public-private partnerships, along with government and HEIs to help students from vastly different social and economic backgrounds to develop competencies needed to align with global industry standards. As Cisco System's largest Corporate Social Responsibility (CSR) education program, CNAP aids in achieving the goal of delivering practical and relevant learning experiences. The CNAP has seen an increase in the participation of developing countries, which have been consistently higher than their more developed counter parts [19]. CNAP constitutes the core curricula for communication network [5,45], this includes network security. In South Africa over 60 HEIs use CNAP as part of their curriculum [48].

Cisco Systems has established partnerships in many developing regions of the world, to deliver sustainable and effective capacity-building programs. In 2000, the Least Developed Countries initiative (LDCi) which established over 58 learning institutions in 20 developing countries, in this particular endeavor Cisco donated CNAP curricula, e-learning infrastructure, and hands-on lab equipment [20,21]. Although the LDCi concluded in 2006, Cisco and its affiliated partners continue to support Institutions that were established within the ITU Centers of Excellence Initiative worldwide. Research from surveys indicates that CNAP has a strong and positive impact within participating communities, especially in developing countries. Most of the students that participated in the surveys found jobs in network related positions after completing the program. More than one in ten students who were surveyed also started their own businesses [22]. "Through this partnership, we have been able to touch more than 1 million students in 51 countries in addition, more than 10 000 students have graduated from the program in Africa" – Alfie Hamid, Regional Corporate Affairs Manager at Cisco Systems [20].

4. Blended Learning at HEI

Elliott [23] argues that the fundamental learning environment has changed, this is largely due to the introduction of technology, and therefore classical pedagogies need to also evolve to reflect this reality. The emergence of ubiquitous computing renders this reality necessary for HEIs. The way information is accessed has dramatically changed due to the increase use of the Internet, which has emerged as the most important tool for e-learning. E-learning covers a spectrum of activities from supported learning to blended learning and to learning that is delivered entirely online.

"Learning environments are becoming more blended in nature as students make choices about whether to attend all traditional face-to-face sessions or to adopt a mix of asynchronous and synchronous activities" [24] Blended learning is a teaching model that comprises of various teaching methods brought together by technology to meet specific objectives. Blended learning is delivered through a combination of personalized online learning, with face-to-face traditional instructor-led onsite support and hands-on application. Through the use of blended learning, students are given control over certain

attributes of learning such as time, place, path and pace [25]; for example, a student might attend classes in a real-world classroom setting, and then supplement the lesson plan by completing online multimedia coursework. As such, the student would only have to physically attend class once a week and would be free to go at their own pace [26].

The use of blended learning has increased in HEI, it is likely to be more widely used in the tertiary and school sectors. In many cases, E-learning component in Blended learning programs is delivered through a virtual learning environment. This virtual environment is constructed for online learning [23]. The new pedagogical challenge is not a lack of information, but rather too much. Students must now learn how to conceptualize and criticize information available on the internet. One of the major benefits of this form of learning is that online learning is accessible from anywhere at any time. It is argued that traditional classroom learning should be better off spent on discussing rather than delivering content [23]. Research shows that students who interact with online learning perform better than students with no such involvement. Furthermore, surveys indicate that students consider online learning beneficial to their studies.

For many developing countries, education is a key factor in remediating poverty and encouraging economic growth [27,28,29]. E-learning is seen as a cornerstone for new delivery methods for education. However, implementing e-learning programs faces a lot of obstacles and challenges in developing countries. According to Khan [30], developing countries are a long way behind developed countries in e-service implementation, and the gap is widening over time. This especially applies to e-learning. Institutions in developing countries are mimicking the trends of e-learning with the expectations of reaping the same benefits enjoyed by institutions in developed countries. Anderson [31] describes several factors that prohibit the successful implementation of e-learning programs in developing countries, these include:

Classical views on education: for e-learning to be fully appreciated, it is essential that classical views on pedagogy be rethought. Classical passive-information-transfer approaches used by HEIs are restrictive when compared to the more interactive student-centered application of e-learning [32]. The problem is that technology in HEIs is seen as just an educational tool, separate from pedagogy. Essentially ICT is a medium for the 'message' (pedagogy), and thus its inter-connectedness should not be seen as isolated [23].

Attitude on IT and e-learning: It is commonly believed that attitudes come from socio-economic views, student's and teacher's views on whether e-learning is 'as good' as traditional face-to-face pedagogies; pose a challenge for e-learning if not addressed openly [33,34,35]. Therefore, the attitude and behaviors that are reflected in a society should permit positively on e-learning development.

Teaching and Learning Activities: This challenge directly refers to the numerous learning activities that may be taken up in a learning environment, activities that are interactive and allow students to collaborate or have a hands-on practical element affect positively on student performance the most [36,37]. In this regard, e-learning is viewed as limited when it comes to assessing student performance.

Support and guidance for students: Support provided by the institution and the teacher is important for the success of the e-learning programs. Students in developing countries usually are not technologically confident, they are neither used to the e-learning culture or distance centered learning, this coupled with the cultural views on e-learning in turn makes them expect the same kind of immediate feedback experienced in traditional face-to-face classrooms teaching [38]. Psycharis [39] elaborates by stating that when new e-learning technologies are adopted, usually little attention is given to student support.

Computer anxiety: According to Tucker, Pigou and Zaugg [40], students with restricted experience on computers are four times more likely to withdraw from the e-learning initiatives, than students who are used to working with them. Many students in developing countries have little to no exposer to ICT solutions, and thus have low levels of confidence and comfort with ICT solutions [41].

Flexibility: One of the major benefits of e-learning is its flexibility, in that it can be used anywhere, anytime and by anyone [23], but this benefit is twofold as it brings out concerns with how much flexibility should be given to the students, such as if student should be allowed to learn at their own pace, when would be the most ideal time to take examination and if students should be allowed choose the medium of content delivery [31] students in developing countries may not have the means to be at school all the time or to have access to ICT solutions, some students may be taking several other subjects at the institution which makes flexibility an issue

Accessibility: The use of the internet for e-learning makes accessibility an enabling or disabling factor. Access is not just restricted to physical infrastructure, it also refers to the accessibility to the content itself, factors such as bandwidth and reliability of internet connection also affects user ability to fully access content, this factor is critical in a student-centered learning environment such as e-learning.

Localization of content: Content provided in e-learning programs must reflect local culture, language and religious beliefs or the content may not be well received by the audience. Much research shows that localization is of benefit for the students and language is often a good predictor of outcome [42,43,44]. For many developing countries English many not be the predominate language used.

5. Implementation of CNAP at HEI

The CNAP plays an important role in helping educate the next generation of network and cybersecurity professionals. The program is essentially collaboration between Cisco Systems and affiliated Institutions. HEIs choose to partner with Cisco Systems for their technical orientated courses. Since the CNAP is a blended learning approach, it usually runs congruently with HEI coursework. Cisco Systems provides the CNAP on-line curricula and on-line assessment free to HEIs. The HEI in turn are required to send instructors to instructor training, monitor student outcomes, and include hands-on activities (hands-on equipment may be donated by Cisco Systems to institutions) in the

classroom [45]. In addition, Cisco Systems also provides a network simulator for students to practice on and for teachers to assess student competence [46].

CNAP content is developed according to a set of learning objectives. Educators have long used learning objectives based on Bloom's Taxonomy. Bloom's Taxonomy is useful for developing learning objectives and ensuring learning outcomes reflect the learning objective. The CNAP learning objectives map well with industry competency frameworks to ensure that student who go through the program develop the necessary competencies required in the field. The most prominent competency framework in cybersecurity is the National Cybersecurity Workforce Framework [4]. The National Cybersecurity Workforce Framework establishes a common taxonomy that can be used to reference cybersecurity related skills. These skills overlap significantly with the CNAP Network Security learning objectives. The CNAP Learning objectives are reflective of the expected competency in the aligned competency as listed by the NCWF. The curriculum thus provides an adequate introduction to the core security concepts and skills needed for the installation, troubleshooting, and monitoring of network devices to maintain the integrity, confidentiality, and availability of data and devices.

Bloom's Taxonomy also provides a convenient way of describing the degree in which educators can expect students to understand in order to demonstrate particular skills. Therefore, it is strategic for teachers to use Bloom's Taxonomy to determine the level of expertise required of students, as this determines which classroom assessment techniques are most appropriate for the course. Bloom's Taxonomy consists of six levels of the cognitive domain, these levels consist of a collective of statement that outlines the learning objectives of an educational program. Usually a learning objective statement will be used to create a set of learning activities. Learning activities are described as activities designed to help students meet the learning objectives. Verbs can be correlated with specific learning activities at specific levels of the cognitive domain to describe the type of learning objectives needed. Van Niekerk and Thomson [5] illustrate how activities currently in the CNAP curricula can be expressed using Bloom's Taxonomy, as depicted in Table 1. The CNAP learning model's cognitive complexity can be expressed not just theoretically, but also from a practical hands-on frame of reference. Student competency is further assessed through practical hands-on exercises, projects and examinations. These practical endeavors assess students' performance at higher levels of degrees in the cognitive domain. During practical exercises students may be required to analyze a network's requirements, and then decide which network protocols are applicable for that specific scenario.

Table 1: Comparing CNAP learning activities to Bloom's Taxonomy

Level	Verb	Sample Activities
Create	design	Design a converged information network to meet the needs of Company A?
Evaluate	critique	Critique these two converged information network

		designs. Which would be best for Company A?
Analyze	analyze	Analyze the given design for a converged information network and determine whether it meets Company A's requirements?
Apply	execute	Implement a converged information network.
Understand	discuss	How does a converged information network differ from the traditional approach of separate networks?
Remember	define	What is the definition of a converged information network?

Other examples of the application of higher levels of the cognitive domain during practical assessment include students evaluating and then implementing specific assess-control statements to suit security requirements given. Practical exercises are based on real-life scenarios and thus translate well into job related competency requirements.

There are many different things to consider when designing and delivering an e-learning program, for an e-learning initiative to be effective it must be of good quality. The Food Agriculture Organisation (FAO) e-learning methodology describes a list of attributes that signify good quality in an e-learning program [47]. As one of the world's largest and most innovative e-learning programs, CNAP captures many of these attributes associated with quality e-learning.

Student-centered content: CNAP learning objectives are based on industry standards and t map well with competency frameworks such as the National Cybersecurity Workforce Framework. Furthermore, CNAP content is based on real-world application, students' part-take in practical exercise and self-assessment quizzes that highlight scenarios that simulate real problems faced by professions in the field.

Granularity: CNAP content is segment into chapters and section for easy assimilation. Each chapter consist of summary and some form of interactive formative assessment to help student assess their progress systematically, chapter exams are taken by students, normally at their own pace, although working within certain limits set by the study calendar.

Engaging content: the CNAP on-line platform uses a wide range of multimedia instructional instruments, this includes interactive video clips, hand-on simulator exercises, discussion boards, multimedia chat, text questions, performance-based reviews, alerts, notifications, blogs, and more. The on-line learning platform can help also enhance instruction and customize courses by embedding content from social media channels. In addition, many tools and guidelines are provided to teachers via the CNAP online management system.

Interactivity: Due to the blended nature of CNAP, student benefit from the self-paced online material and the traditional classroom environment. In addition, career support is also provided to students via the CNAP on-line platform, such as Career Path assistance, Job hunting resources and motivational success stories from graduates.

Personalization: Students are provided with a number of tools to customize their learning experience to meet their self-paced needs, this includes dashboards where they can oversee and schedule events such as quizzes and chapter exams. Teachers are able to keep track of each student's performance through an on-line gradebook.

6. Discussion

The is a need to incorporate competency-centered programs in cybersecurity related courses by HEIs, these learning programs need to be measurable against a well-defined industry competency framework and delivered through sound pedagogical means. Through CNAP, Cisco Systems together with HEIs has been able to effectively deliver and implement an e-learning program that is measurable and pedagogically sound, while ensuring that the program is robust enough to also be provided in developing countries. As such, these following factors serve to validate this argument.

- **Meeting competency:** CNAP learning objectives are measurable against the National Cybersecurity Workforce Framework.
- **Sound Pedagogy:** CNAP learning activities adheres to the Bloom taxonomy model's view on strategic student assessment.
- **Effective delivery:** CNAP e-learning aspects consist of many characteristics of a quality e-learning program as defined by FAO e-learning methodology.
- **Anticipating challenges:** Cisco Systems has made efforts in identifying and addressing factors that may prohibit the successful adoption and delivery of CNAP.

CNAP has seen much success in many HEIs, since its initial conception over a million students have participated in the program with over 5% being from Africa [45]. Statistic indicate a steady and progressive completion rate in developing countries, although less than in developed countries. The study also concluded that there was a strong correlation between a country's successful CNAP student participation and its networking skills readiness [6]. Interestingly in another independent study it was indicated that instructor quality and use of technology tools, where the strong factors in determining the successful adoption and implementation of CNAP [45]. Therefore, successfully addressing instructor quality and use of technology tools could directly or indirectly contribute a country's networking skills readiness. Since developed countries have shown a stronger CNAP student participation then developing countries, in could be conceived that these institutions may have stronger instructors and/or technology tools, research into how they have accomplished this could help developed countries improve their own CNAP.

7. Conclusion

CNAP has in many ways been able to effectively adopt and implement e-learning platforms in HEIs to help these institutions produce competent graduates. Competencies gained through CNAP are able to be leveraged in order to find job placement. As such, the CNAP complements efforts of addressing the skills shortage crisis, in fact CNAP involvement could be considered an indicator of a country's network skills capacity or its propensity to invest in technology education.

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