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**| RESEARCH ARTICLE**

# A Portable Computer Network Laboratory Model for Competency-Based Curriculum

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**| ABSTRACT**
Computer networking technology has greatly evolved and continues to be an integral part of different aspects of our lives. The technology is no longer confined to business settings but is now predominant in personal and home devices. This has created a surge of career opportunities and consequently created a demand for manpower with a matching skill set for supporting the data networks that depend on these technologies. A competency-based curriculum (CBC) is a paradigm shift in education that transforms the conventional learning processes by promoting hands-on learner experiences and the traditional emphasis on basic networking principles. Experimental learning within a lab environment is essential to reinforcing computer networking knowledge and to ascertain that the learner is mastering content as well as getting better at what they are doing. CBC has great potential and is likely to transform examination-based learning, which results in less innovation at all levels of education. One of the challenges of learning computer networking is the provision of and access to networking laboratory equipment. This paper addresses this gap by proposing a portable computer network laboratory that will support the delivery of a competency-based computer network engineering curriculum.

**| KEYWORDS**

Competency-based learning, portable network laboratory, experiential learning

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## 1. Introduction

A competency-based curriculum focuses on the complex outcomes of a learning process, including knowledge, skills, and attitudes to be utilized by learners as opposed to the knowledge-based curriculum, which focuses on what learners are required to learn in the subject content. The underlying principle of a competency-based curriculum is learner-centred and adapts to the dynamic needs of the students, teachers, and society. According to Kabombwe and Mulenga (2019), the emphasis of a competency-based curriculum is for learners to gain and apply the knowledge, skills, values, and attitudes to solve problems and challenges that they encounter in daily life. In their article, Scheopner Torres et al. (2018) point out that the goal of competency education is "to meet the needs of students more effectively by demanding student mastery of rigorous content and skills rather than measuring student learning by the amount of time a student has received instruction". Proponents of the competency-based curriculum highlight that it adopts practices that improve students' learning, such as consideration of their background knowledge to pace instruction, utilizing formative assessments and mistakes as opportunities to lead, creating intrinsic motivation to learn, and focus on the assessment that assesses the application and deeper learning as opposed to basic skills. The competency-based curriculum is considered a means of gaining the skills and knowledge required for economic growth and development in the country (Wafubwa, 2021). The KICD indicates that within the Kenyan context, each learner is expected to attain seven core competencies that include communication and collaboration; self-efficacy; critical thinking and problem-solving; creativity and imagination; citizenship; digital literacy; and learning to learn. One of the elements that are incorporated in competency-based technology is computing technology and ICT. However, most learning institutions lack the resources to offer a practical learning approach in computing technology. This paper provides an overview of how learning institutions can build portable networking engineering laboratories that will enable learners to gain hands-on experience.

### *1.1 Problem Statement*

The rapid growth and application of ICT have seen it become a critical element in the curricula of many learning institutions. Currently, institutions are focusing on impacting ICT skills to the learners in a classroom set-up with the hope that they can apply them in a 21st-century workplace. Whereas the competency-based curriculum emphasizes a practical approach to learning, most learning institutions face challenges in providing a hands-on network learning environment. Montero and Manzano (2017) point out that computer network engineering is critical in computer science and information technology curricula. Learners need computer network engineering labs to help them gain the necessary skills to effectively navigate around the rapidly changing computing technology. However, setting up network engineering labs is expensive, which prompts most learning institutions to fail to engage the students in the practical activities, which creates a gap in their learning process. This leads to a mismatch between the requirements of real practice of network engineering and the academic process of teaching learners with network engineering skills. It is thus evident that a solution is needed to provide a cost-effective lab for learners to gain hands-on experience in computer networks.

## 2. Literature Review

Research on the implementation of competency-based learning has enumerated several benefits over traditional learning. A competency-based curriculum is essential for adequately preparing learners for their future roles by enhancing their problem solving, creativity, imagination, communication, and collaboration skills. Despite the identified advantages of a competency-based curriculum, integrating educational technology in the school curriculum faces numerous operational hindrances which usually affect its feasibility (Karthikeyan, 2020). Murithi and Yoo (2021) note that governments all over the world have made investments to integrate ICT in education at all levels to enable learners to gain practical skills needed for modern life. Investment in education technology has positively impacted nations such as South Korea, which has recorded extraordinary economic growth (Murithi and Yoo, 2021).

Computer networks are key ICT components that are required to enhance the functional performance of different sections and organizations. According to Sabin et al. (2018), there is a need for learning institutions to provide competency-driven learning as opposed to the delivery of purely theoretical knowledge. The emphasis on such competencies would help the institutions engage the learners in professional practice experiences. A learning laboratory is a valuable tool for teaching networking concepts to achieve competency-based learning for computer networking. According to Dewar and Sethi (1995), a laboratory for computer networking provides opportunities for students to understand how different network engineering principles operate and the types of behaviours the networks exhibit. El-Kharash et al. (2002) emphasized the importance of computer laboratories in learning by pointing out that they allow learners to learn how to internalize formal specifications for a network project as well as offer them a comprehensive environment to develop software for a network, test, and debug it, and understand its working behaviour. In a lab environment, the learners get an opportunity to interact with hardware to gain a hands-on understanding of how data and its representative signals move in a network. Therefore, having access to a network engineering lab is essential to facilitating a practical approach to learning.

Real practical learning and teaching approach has been noted to be effective in assisting learners to acquire the much-needed skills in computer networking. A study by Sarkar (2006) on the use of practical laboratory exercises as part of the computer networking curriculum concludes that learners learn more effectively from the courses involving practical tasks such as configuring and installing servers. Shimba, Mahenge, and Sanga (2017) identified that the use of computer network simulators could be used to facilitate teaching and learning computer networking by being involved in the development of computer network models. However, they note that learners, when engaged using physical computer networks, gain hands-on experience that would not have been gained through computer network simulators. Similar findings were noted by Nedic et al. (2003), who argued that while some software packages have proven to be useful in simulating real experiments, learners can gain more from the learning process involving practical activities. Among the reasons why focusing on practical learning is good for the learners include creating interest to learners, helping learners to develop critical and logical thinking, and helping learners understand the scientific processes, concepts, and phenomena easily" (Nedic et al., 2003). Hands-on labs provide an ideal learning experience, where the students are in a position to interact with materials or data to observe, investigate, and understand the operation of the natural world. Therefore, a learning laboratory is an effective teaching tool that offers the learners an opportunity to get a realistic experience.

A theoretical framework that supports the use of hands-on experience in learning is the Experiential Learning Theory (ELT) by David Kolb. The four stages of ELT are concrete learning, reflective observation, abstract conceptualization, and active experimentation. According to Kolb (1984), ELT is a process whereby knowledge is created through the transformation of experience. Under this theory, Kolb described that the learning process is more effective when learners get a chance to connect with concepts at each stage, which helps them retain more information and develop critical thinking abilities (Jenkins & Clarke, 2017). McCarthy (2010) describes ELT as a holistic, adaptive process of learning that merges experience, perception, cognition, and behaviour. Experiential

Learning Theory makes several propositions about learning. Learning is considered as a process, not in terms of outcomes, which means that to improve learning in education, the primary focus should be on engaging students in a process to enhance their learning. All learning is re-learning, which means that individual constructs make sense from their experience. Learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world. Learning is the holistic process of adaptation. Learning encompasses thinking, feeling, and perceiving; learning results from a synergetic transaction between the learner and the environment. Finally, learning is the process of creating knowledge and not knowledge transmission (Shimba, Mahenge, and Sanga, 2017). Thus, a competency-based curriculum that adopts a hands-on approach to learning rhymes with the Experiential Learning Theory (ELT).

**3. Methodology**

A key challenge hindering the implementation of a competence-based curriculum in teaching network engineering is the high costs of building a complete laboratory to support a practical learning experience. This paper proposes a solution to this challenge in the form of designing and developing a cost-effective portable network engineering lab. The network engineering lab is in line with the PDIOO standard, the industry standard for computer network systems design and implementation as Priscilla (2010) provided. The portable network engineering lab is fabricated on an aluminium trolley that can be shifted from one location to another. Learners will have an opportunity to physically connect to the network lab through patch cords or wirelessly through Wi-Fi. In the network engineering lab, the internet working devices will be placed on the portable rack with modules that can be rearranged, reduced, or added based on the specific needs of a lab experiment. This portable lab can be utilized for computer science and information technology-related curriculums.

The hardware components required for the model comprise three routers with a base, two switches, one wireless router, one Linux rack server, one Windows rack server, one portable Rack Cabinet, a cable crimping and testing kit, and a console

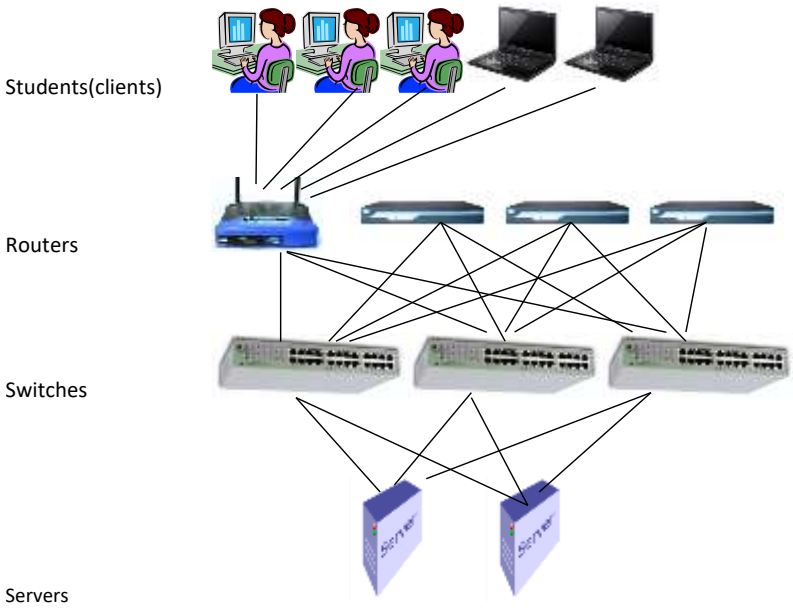


Figure 1 - Network Lab Physical Design (Source: )

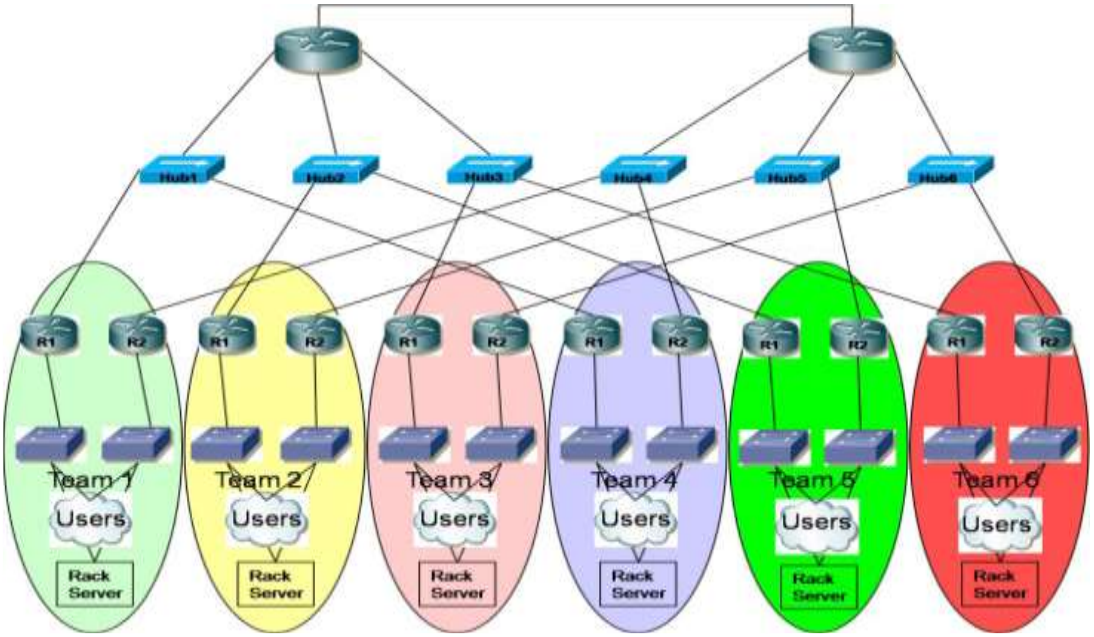


Figure 2- Network Lab Logical Design


Figure 3 -A Prototype of the Proposed Portable Network Lab

## 4. Results

The study investigated the impact of using a portable network engineering lab model on learners by assessing their competency. This was in the light of comparing their understanding of basic network engineering principles and matching it against the learners' ability to implement these basic principles in a laboratory environment. The data collected and analyzed was based on the student performance in the continuous assessment tests and at the end of semester examinations for undergraduate students. The study's objective was to design and develop a portable network engineering laboratory model and subject it to a competency-based curriculum. At the current stage of research, a working prototype has been developed and deployed for use in Meru University of Science and Technology. After the end of the current semester, a longitudinal analysis shall be carried out in comparison with the results of the previous semester.

## 5. Conclusion

Learners can gain more from a learning process where practical activities are involved. A functional laboratory is a basic requirement for any institution that intends to effectively deliver on the teaching of computer network engineering. However, most learning institutions lack sufficient resources to develop a fully-fledged network laboratory. This article proposes a solution in the form of designing and developing a cost-effective portable network engineering laboratory. The portable network engineering laboratory is ideal for conducting experiments that need networking competencies such as cyber security, CCTV, IP Telephony, IoT, Robotics, Cloud Computing, Live streaming, and other emerging technologies in the realm of computing and ICT. In a laboratory environment, the learners get an opportunity to interact with networking hardware and gain hands-on skills that can be put into practice.

## References


[1] Dewar, W. J., & Sethi, S. S. (1995). A laboratory for teaching computer networks. *IEEE Transactions on Education*, *38*(2), 145-149.

[2] El-Kharashi, M. W., Darling, G., Marykuca, B., & Shoja, G. C. (2002). Understanding and implementing computer network protocols through a lab project. *IEEE Transactions on Education*, *45*(3), 276-284.

[3] Jenkins, J. J., & Clarke, T. (2017). Engaged Journalism: Using Experiential Learning Theory (ELT) for In-Class Journaling Activities. *International Journal of Teaching and Learning in Higher Education*, *29*(1), 154-161.

[4] Kabombwe, Y. M., & Mulenga, I. M. (2019). Implementation of the competency-based curriculum by teachers of History in selected Secondary Schools in Lusaka district, Zambia. *Yesterday and today*, *(22),* 19-41.

[5] Karthikeyan, K.C. (2020). Challenges of Integrating ICT into the School Curriculum as per the Policy of NEP 19. 10.13140/RG.2.2.35480.83203

[6] Kolb, D. A. (1984). Experiential learning: Experience as the source of learning and development. Englewood Cliffs, NJ: Prentice-Hall.

[7] Montero, M., & Manzano, D. R. (2017). Design and deployment of hands-on network lab experiments for computer science engineers. *Int. J. of Engineering Educ*, *33*, 855-64.

[8] Murithi, J., & Yoo, J. E. (2021). Teachers' use of ICT in implementing the competency-based curriculum in Kenyan public primary schools. *Innovation and Education*, *3*(1), 1-11.

[9] McCarthy, M. (2010). Experiential learning theory: From theory to practice. *Journal of Business & Economics Research (JBER)*, *8*(5).

[10] Nedic, Z., Machotka, J., & Nafalski, A. (2003). Remote laboratories versus virtual and real laboratories. https://doi.org/10.1109/fie.2003.1263343

[11] Sabin, M., Alrumaih, H., & Impagliazzo, J. (2018). A competency-based approach toward curricular guidelines for information technology education. In *2018 IEEE Global Engineering Education Conference (EDUCON)* (pp. 1214-1221). IEEE.

[12] Priscilla, O. (2010). Top-Down Network Design.

[13] Sarkar, N. I. (2006). Teaching computer networking fundamentals using practical laboratory exercises. IEEE Transactions on Education, 49(2), 285-291. https://doi.org/10.1109/TE.2006.873967

[14] Shimba, M., Mahenge, M. P., & Sanga, C. A. (2017). Virtual labs versus hands-on labs for teaching and learning computer networking: A comparison study. *International Journal of Research Studies in Educational Technology*, *6*(1), 43-58.

[15] Scheopner T, A., Brett, J., Cox, J., & Greller, S. (2018). Competency education implementation: Examining the influence of contextual forces in three New Hampshire secondary schools. *AERA Open*, *4*(2), 2332858418782883.

[16] Wafubwa, R. N. (2021). Challenges of Teaching and Assessing the 21st-Century Competencies in Africa: A focus on the Kenyan New Curriculum of Basic Education. *East African Journal of Education Studies*, *3*(1), 96