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Influence of Virtual Physics Laboratory on Transfer of Skills Training: Connection Accuracy and Speed

[1]Omosa Elijah Mochama [2]Dr. Ezekiel N. Omwenga [2].Dr. Enock M. Obuba

[1]Department of Physics, Kisii University, Kenya
[2]Department of Curriculum, Instruction and Educational Media, Kisii University, Kenya
Email:eomwenga@kisiiuniversity.ac.ke

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***Abstract**: The study investigated the influence of virtual Physics laboratory on speed and accuracy of connection of electric circuits by trainees from Craft Certificate in Science Laboratory Technology (CCSLT) in tertiary institutions in Kenya. The target population was all the trainees in the CCSLT course and their trainers. The sample consisted of 53 Second Year Physics trainees and four trainers from The Kisii National Polytechnic. A quasi-experimental design with the experimental (virtual-lab) (N= 27) and control (no-virtual-lab) (N=26) groups, was used. The virtual lab group practiced in a virtual lab while the no-virtual-lab group used the Conventional Laboratory. Both groups were subjected to a pretest and a post-test lab test using a Practical test observation checklist. Experts approved the experiment before use. A Spearman's Correlation Coefficient, r = 0.94 was obtained. A t-test, means and standard deviations to test two null hypotheses at 0.05 levels of significance. The t_{cal} = 0.056, df = 50, p = 0.956; Cohen's d = 0.02; implies the mean scores in connection accuracy between the virtual lab and the non-virtual lab trainees in the post-test were not significantly different. The t_{cal} = - 4.391, df = 50, p = 0.000; with Cohen's d = -1.22; the virtual lab trainees recorded significantly shorter mean time of circuit connection than the non-virtual lab trainees. The study recommends that trainees should be granted an opportunity to engage in virtual hands-on Physics to supplement physical laboratories.*

***Keywords:** Connection accuracy, Connection speed, Skills transfer, TVET, Virtual laboratory*

1. Introduction

Education in science and technology enables an individual to become knowledgeable and to develop relevant skills that enhance individual productivity and quality living for a nation (Porter, Ketels & Delgado, 2007; Farooq, Chaudhry, Shafiq & Berhanu, 2011; Government of Kenya, 2007). Several challenges facing modern society such as: climatic changes, emerging diseases, housing, security, terrorism, genetically modified organisms, energy and population crises and others such as biotechnology need Physics knowledge so that they can be handled rationally (UNESCO, 2010). Physics is a science that deals with matter and its relation to energy. It draws its content from experiments, critique, and rational discussions. The understanding of its concepts, laws, principles and theories are based on the perception of the Physical phenomena (Ayoubi, 2018).

However, the low enrollment and the dismal achievement in Physics techniques at Kenya National Examinations Council (KNEC) for Craft Certificate in Science Laboratory Technology (CCSLT) course in tertiary education implies that the way the practicals are handled needs to be relooked at (Kenya National Examinations Council CCSLT Report, 2010, 2012, 2018).

Laboratory work is a form of David Kolb's experiential learning models. The place of laboratory education in science (especially Physics) and engineering courses cannot be overemphasized and it has been well documented (Hofstein & Kind, 2012). Balamuralithara and Woods (2009) maintain that the laboratory needs to supply students with real world practical aspects that can be applied to the real workplace. According to Trundle and Bell (2010), when the theoretical information in a hands-on activity is not comprehended by the students, they do not retain it and accordingly, this leads to disappointment in the subject they are studying. Thus, they create negative attitude towards the subject. It is important, in the subject of Physics that dynamic thoughts are recognized with actual life occasions, prolonged mathematical calculations are moved towards all the greater inventively and the weight of practice in the laboratory (Çelik & Karamustafaoğlu, 2016). Physical laboratories cannot be used effectively due to reasons like few schools have them, the cost of setting them up and maintain and the inadequacy or lack of tools (Tatlı & Ayas, 2013). Wolf (2010), posits that the cost of carrying out experiments in terms of planning and executing hands-on activities is high, and practical sessions takes a lot of time and is also tedious on the part of the teacher. Performance by trainees throughout the experiments in laboratory cannot easily be checked by the teacher due to the fact that it is time consuming and laborious particularly where massive numbers of students are concerned (Tüysüz, 2010). These cannot effortlessly be afforded with the aid of the already heavily resource constrained technical training institutions. A study by Akeyo and Achieng (2012) find the same factors hindering hands-on for trainees in the technical training institutions in Kenya.

When these challenges are taken into consideration, it becomes inevitable that an alternative that may work better be looked for, hence, the use of v-labs has been suggested (Trundle & Bell, 2010). A v-lab that seems to make contributions to constructing knowledge is becoming more acceptable because: it has many applications in education, simulations based on Physics that copy natural phenomena and conditions in experiments (Tatli & Ayas, 2013). Simulations offer the user the chance of interacting with it, manipulate situations and values, get immediate feedback, and use of multiple representations (Mwamba, George, Moonga & Pondo, 2019). However, researchers appear not to agree wholly on the effectiveness of v-labs in teaching and learning (Corter, Nickerson, Esche, Chassapis & Ma, 2007). There is a big debate on the effectiveness of v-labs in the education of practical skills. The quantitative research investigated the influence of virtual laboratory on transfer of skills – connection speed and accuracy of set electric circuits.

1.2 Statement of the Problem

Physics experiments are not often carried out in some tertiary technical training colleges in Kenya because of the inadequacy or lack of real physical equipment (Akeyo & Achieng, 2012). To alleviate these problem virtual laboratories have been suggested. However, there is a massive debate on their effectiveness in skills training with some researchers feeling that the v-labs contribute positively while others see the otherwise. There is little literature on the influence of use of v-labs in TVET on learning outcomes at the tertiary level. Much literature that is available is in either the secondary segment of education or the university. Before any technology can be utilized, it is imperative to establish that it will obtain that which it claims to. This is as far as issues of the use of v-labs for conducting Physics practical influences transfer of skills – by measuring the accuracy and speed of connection of real circuits and its potential as a replacement or a complement for physical laboratory activities at the tertiary segment of education in Kenya. Therefore, this study aimed at finding out the influence of the use of v-labs in training CCSLT trainees. Specifically, it examined how v-labs influence the acquisition of technical skills in electric and electronic circuitry while using the quantitative strategy in a bid to improve the learning outcomes in the subject in TVET at this level of education.

Objectives of the Study

The study sought to achieve the following two objectives:

1. To establish if there is a statistically significant difference in the accuracy of connecting physical circuit components and equipment between trainees who practiced in a virtual lab prior to practicing in a real lab and trainees who did not practice in a virtual lab prior to practicing in a real lab.
2. To find out if there is a statistically significant difference in the mean times taken to connect physical circuit components and equipment between trainees who practiced in a virtual lab prior to practicing in a real lab and trainees who did not practice in a virtual lab prior to practicing in a real lab.

Research Hypotheses

The following research hypotheses were formulated and tested in this study at significance alpha level of 0.05:

H_{01}: There is no statistically significant difference in the mean score in accuracy of connecting physical circuit components and equipment between trainees who practiced in a virtual lab prior to practicing in a real lab and trainees who did not practice in a virtual lab prior to practicing in a real lab.

H_{02}: There is no statistically significant difference in the mean times taken to connect physical circuit components and equipment between trainees who practiced in a virtual lab prior to practicing in a real lab and trainees who did not practice in a virtual lab prior to practicing in a real lab.

2. Literature Review

2.1 Virtual laboratories in Skills Training – Accuracy of connection

Information Communication Technology (ICTs) have an unmistakable part in enhancing nature of instruction and learning (Fathima, 2013) and in changing the worldwide status of classroom teaching (Sasidharakurup, Radhamani, Kumar, Nizar, Achuthan & Diwakar, 2015). It is considered that ICT is a versatile source of scientific information, theoretical information and offers a viable means for supporting learning authetically in science-chemistry (Awad, 2014). Virtual labs have typically been utilized as a part of training abilities in fields requiring safety before trainees are permitted to practice on the real equipment. They can also assist in lowering costs, for example, in science and engineering at all levels of learning (Akpan & Strayer, 2010). Pilot training, military equipment training, medical training and nuclear power plant training have relied on these simulators or v-labs as suggested in research. A flight simulator for example is a virtual world in which an aircraft is simulated with its environment and all events occurring where it flies (Haslbeck, Kirchner, Schubert & Bengler, 2014). Regardless of expansion of virtual laboratory software, there have been few publications trying to gauge skills attainment in virtual laboratories (Aggarwal, Ward, Balasundaram, Sains, Athanasiou & Darzi, 2007). Cannon-Bowers (2007), posit that to address the issue of optimal utilization of innovation, the confluence of innovation, content, student qualities and pedagogical principles must be basically considered. Virtual laboratories have been touted for bearing novices the fail-safe module capacity errors (Duarte, Butz, Miller & Mahalingam, 2008). Amateurs in skills training are more likely to make errors in their execution of assignments. In sensitive systems, for instance, PC networks, students are not given a real system to exercise and fail as it is being utilized by clients on the other end (Duarte et al., 2008).

In the physical experimental lab, it can be a test to incorporate learning by way of disappointment in the training for a few reasons. The potential to rapidly arrange, disconnect and reconfigure circuits supposedly is a component in improving mistakes made by the trainees and aiming towards perfection in skills gaining according to Mayer and Johnson, (2010).Virtual labs have been connected to the potential to rapidly arrange, disconnect and reconfigure circuits supposedly is a component in improving mistakes made by the trainees and aiming towards perfection in skills gaining (Mayer & Johnson, 2010). Dissections of a virtual frog have been previously compared with real life specimen in real laboratories with these numerous studies having mixed results while others show that real dissections are superior (Cross & Cross, 2004), while still others (Akpan & Strayer, 2010) suggest that learners should be exposed to integrated labs.

Anisetti et al. (2007) explains that when used as a piece of training in vocation and specific training programs, virtual laboratories are used to make trainee capacity in the execution of practical skills. The training should add trainees with the skills to work out career related assignments that trainees may additionally be meeting in real work setting. For instance, in PC net technicians are equipped with the capabilities that will make them able to configure, manage, troubleshoot, and monitor actual PC networks (Anisetti et al., 2007). The conceptual and hypothetical performance of PC networks is integral and no longer adequate (Frezzo, 2009). Learners ought to have the capacity to function hands-on tasks (Frezzo, 2009). In a classroom-based case study, Frezzo (2009), used the Cisco's computer network virtual lab (Packet Tracer®) found that students securing arranging, actualizing, and troubleshooting skills when taught in an activity-based technique. Likewise, learners could develop elaborate network models in self-coordinated request sessions. In any case, occasionally the clarity of the objective of using v-labs could be hindered by effort taken in learning how to utilize the software (Frezzo, 2009).

V-labs cannot replace traditional laboratories but can respond to the existing challenges and optimize the learning process. Students can gain by v-labs when discovering about their real environment, as they gain content and create science process skills (Jaakkola, Nurmi & Veermans 2011; Lampi, 2013; Peffer, Beckler, Schunn, Renken & Revak, 2015). There is evidence that a combination of physical and virtual laboratories work better than any one singly (de Jong, Linn & Zacharia, 2013; Chiu, Dejaegher & Chao 2015; Jolley, Wilson, Kelso, O'Brien & Mason, 2016). More worries about students getting tied up in figuring out how to associate with the PC simulator as opposed to investigating the topic (Frezzo, 2009). Additionally, Dalgarno, Bishop, Adlong and Bedgood (2009) affirm the fact that the real lab was more viable than the v-lab; real lab learners are seen to be scoring better than v-lab students. The results of the study propose that the learning that results from experimenting in the real lab is more effective than investigating the virtual lab, yet the distinction was somewhat little. Critics have pointed out that when external stimuli are oversimplified it may lead to students to developing an incorrect view of reality.

Students' training in technical skills that encompass monitoring and maintenance of systems that require elite dependability need to accomplish the capacity to perceive, investigate, and settle flaws. These flaws might be commonplace or new to them. Training and consequent working experience ought to be supposed to open students on the other hand many disappointment instances as would be prudent (Kluge, Sauer, Burkolter & Ritzmann, 2010). Transfer of training is the extent of retention and utility of the knowledge, skills, and attitudes from the training environment to the place of actual job environment (Kluge et al., 2010). Handling of unfamiliar occasions due to the past presentation of comparable ones in training is recognized as adaptive transfer (Kluge et al., 2010).

Technicians who maintain and repair electric and electronic equipment have to routinely correct system faults. Access to physical equipment and real life failure circumstances can be a bottle neck in this undertaking. There is a slight departure in this study as compared to others in that it aims to gauge the amount of skills transfer from virtual lab to real equipment and the eagerness for this training. This is typically estimated utilizing the transfer effective evaluation method (TEE). A TEE consist of an experiment for learning and a transfer experiment (Morrison & Hammon, 2000). Transfer of training in pilot training is measured by the equation:

$$T = \frac{E - c}{c} \times 100\%$$

(Morrison & Hammon, 2000, p. IV 11)

where c represents average score of the control group and E is the average of the experimental group.

Other than the fact that the debate about the virtual labs being inconclusive, there was little literature available as concerns the utilization of virtual labs in the tertiary level. Besides, e-labs application in educating and learning physics, electricity and electronics specifically, fails in meeting the TVET segment requirements, as most virtual laboratories in physics are made for secondary schools and universities. There are very few virtual laboratories that can be used for teaching the selected topics in Physics (electricity and electronics) at the tertiary level. Thinking about this constrained application, the researcher feels that e-labs can't replace conventional labs yet can respond to the current difficulties and advance the process of learning. Models of Computer and simulations, at this point, are dealt with as helper intellectual devices to get experimental and scientific skills, and in building up an ability of interpretation and analyzing experimental results, particularly amid pre-lab addresses.

The experimental group executed the experiments in the virtual laboratory. The control group did not do any v-lab training earlier but they undergo training in the actual lab but used the physical ones to perform circuitry experiment connections.

2.2 Virtual laboratories in Skills Training – Speed of connection

An investigation done by the department of defense established that trainees practicing in virtual laboratories improved transfer to real-world setting (Morrison & Hammon, 2000). Elliott, Welsh, Ibeck, and Mills (2007) established that fire fighters can gain skills in decision making via v-labs as well as indicating modifications in factors such as accuracy, speed, efficiency and planning. Moreover, trainees’ connection of electrical circuits using a virtual laboratory transferred their competencies to the real lab (Finkelstein et al., 2005). In pilot training, students' education on a computer have shown transfer of competencies to a real airplane. Ericson (1993) explains that in the training in skills, transition from beginner to expert is executed through a deliberate and repetitive practice in quite a number circumstances. Virtual lab offers newcomers the additional opportunity to work on permitting them many times to navigate over a similar area of information. Virtual labs do not only save time and space but allow learners to arrange the apparatus as required (Akpan & Strayer, 2010). Anderson and Pearson (1984) tested that such practice administrations follow a negative power rule;

$$T = BN^{-k},$$

where T is the time to perform task, k is the rate of learning parameter, B is the initial overall performance on undertaking before training, and N is the number of learning trials. Electric and electronic circuitry and measurement is an adaptive skill.

Virtual laboratory opponents contend that the degree of fidelity had frequently not indicated the distinction of execution and skills actualization in the real world. In actual life, assignments are carried out in atmospheres that have several associating aspects that cannot be incorporated into a virtual laboratory (Akpan & Strayer, 2010). The virtual laboratory enhances the theory with the aid of giving a dynamic feel of the idealized system (Akpan & Strayer, 2010). Students who get trained in virtual laboratories do not experience the commotion and obstruction that goes with actual measurement. Past studies did not report effect sizes in the results or discussion sections, apart from the investigation by Métrailler, Reijnen, Kneser and Opwis (2008) and Lampi (2013). Sadly, price of this high fidelity virtual laboratory is over $30, 000, contradicting the proclamation that virtual laboratories are lower-priced (Issenberg & Scalese, 2008). Brinson (2015) audits empirical studies in the post-2005 reports inconsistencies between the goals of the teachers, expectations by the learners and outcomes out of the learning across the domains of meaningful learning: affective, psychomotor and cognitive have been revealed by numerous researches (DeKorver & Towns 2016; Galloway & Bretz 2015a, 2015b).

It can be seen from the literature reviewed, that there is an inconclusive debate on the eefectiveness of the virtual labs on the training of technical skills, with some researchers proposing that they are superior to the physical laboratories with yet another group maintaining that a blend of the two will work best. The researchers in this study have feelings that there are situations in which the practical skills may be well trained by applying the v-labs, but again sections of practical skills cannot be learnt purely by v-labs as they may not at times meet the needs of learners fully for hands-on experience. Again v-labs sometimes create a misconception in practical work, in that learners may not realize where really dangers may arise in the actual situations, therefore transfer from virtual to real labs may not fully be possible. An augmented form may work best in technical training where both v-labs and physical ones supplement one another. Further that the trainers should view the v-labs as a vehicle with which to deliver content and not as an end in itself. It then became necessary to design a research that will bring out the truth about transfer of skills and especially in the tertiary level of education where much research has not been conducted. However, not many of the studies have delved into skills transfer. This study dealt with the influence of virtual laboratory on the Craft Certificate in Science Laboratory and Technology trainees' transfer of training.

3. Methodology

3.1 Research Design

The study applied the quasi-experimental research design of the non-equivalent pre-test, post-test, control group and experimental type.

3.2 Sample and Sampling Techniques

The sample for the study was made up of 53 Craft Certificate in Science Laboratory Technology Second Year Physics students, in The Kisii National Polytechnic, Kenya; 16 male and 37 female trainees. These classes were randomly assigned to the two groups. Pre-test - Post-test was used to check the effect of the treatment. Four trainers were also sampled; two for the control class and two for the experimental class. Equally, a practical observation checklist was used to check the learning of the selected learning outcomes. Second Year class was chosen because at this point the trainees had been introduced to Physics as a subject and Physics practicals in Year One. Table 1 shows the experimental and control groups.

Table 1. Experimental design adopted

	Observation 1	**Treatment**	**Observation 2- Practical**	**PT2 – PT1**
Group 1: Experimental-Virtual-lab	Pre-test, PT1; Practical	Virtual Lab Practice (5 trials)	Post-test, PT2	
Group 2: Control-Non-virtual-lab	Pre-test, PT1; Practical	Real Lab Practice (5 trials)	Post-test, PT2	

Source: Field, (2020)

Here two intact classes of the Second Year CCSLT trainees of the Kisii National Polytechnic, Kenya were assigned randomly to the control and experimental groups. The group in experimental (v-lab, N = 27) practised in the virtual laboratory while the control (no-virtual-lab, N = 26) group was subjected to physical Physics laboratory. Both groups were involved in identical pre-tests and post-test (practical test). The experimental group had 8 males and 19 females at the start but one female trainee did not stay up to completion of the study. The control (non-virtual) group had 8 males and 18 females.

3.3 Research Instruments

*(i) Treatment – The Virtual Lab Experiments:*The DCAC Circuits Online Virtual Laboratory having experiments on the topics current electricity and electronics fitting in to the purpose of the study was used. These simulations allow students to vary such as resistance, current, voltage, and it allows them to receive real-time feedback on the results of changes to the experimental set-up. A two-hour orientation session about how to use the website, its components, and the website link was given to trainees via Physics trainer. In the orientation session, each trainee was provided with his/her user name and password for accessing the website, in addition login and using online laboratory. During the implementation period, students in the control group studied the same content as those in the experimental group, except that they did not use the Virtual Lab learning activities. Their learning activities included classroom lectures and related activities and physical laboratory experiments. For both groups, a Physics Practicals Training Module which consisted of the experiments to be followed when teaching the topics electricity and electronics were designed, developed and evaluated for use.

(ii) Practical Skills Assessment Tool – Checklist; This method was used to get firsthand information by observing trainees and record as the practical procedures were being carried out by the trainees at site. The tool was designed

by the researcher for making observations for the trainees who practised in both physical and v-labs for checking how the trainees went through the practical skills test. Each practical test lesson lasted for about one hundred and twenty minutes. This observation gave the researcher an opportunity to record activities as they occur during the practical test lesson. These are the pace with which the trainee connects the wires, one's accuracy of connection, taking measurements and recording them, choice of materials and equipment and general workmanship on the test experiment.

The research tools were validated by experts. To ensure the reliability of the research instruments, piloting was done on two trainers of the Year Three (3) class - 20 trainees, a class that was just ahead of the sample class because the students therein had similar characteristics to the sample class. The test-retest method was utilized for the Practical Test Assessment tool – checklist. The instrument was administered to the Physics trainers and trainees, the items were reshuffled and administered again after two weeks. The Pearson product-moment correlation coefficient for the tool was computed as 0.94.

3.4 Method of Data Collection

The researchers sought permission and cooperation from The Kisii National Polytechnic to conduct the study there. The sampled trainers were trained by the lead researcher and made to be research assistants; two in the experimental group and the other two were research assistants in the control group. Pre-test using Physics Practical test testing on the pre-requisites for learning the topics electricity and electronics circuits was done to both groups to check whether there were significant differences. The lead researcher scored the pre-test out of 25 marks. The experimental group covered the Physics practical content through a virtual laboratory. The participants in the control group did identical experiments in a physical lab using physical equipment and materials. After the six weeks of treatment the researchers with the assistance of the research assistants administered the post-test to both the control and the experimental groups and evaluated just like the pretest.

3.5 Data Analysis

The data obtained was analyzed using the Statistical Package for the Social Sciences (SPSS) - version 23.0. An independent student's t-test was applied to determine whether there was any difference in learners' performance between the group exposed to virtual Physics laboratories and those who were not. Cohen's d was also calculated to check on the strength of the effect of the treatment of the virtual lab on the trainees.

4. Results and Discussion

4.1 Virtual laboratories in Skills Training-Accuracy of Connection

The first null hypothesis; That is, to determine whether there is a statistically significant difference between the mean score in post-test scores in accuracy of connection of circuit by Physics of the trainees exposed to the virtual Physics laboratory and those exposed to the physical Physics laboratory. Here the independent variable is the type of laboratory of the two groups and the score out of 25 marks that a trainee attains in the practical test set circuit connection is the dependent variable. A t-test on pretest scores for speed of connection showed that the trainees in either group were equivalent before the treatment. The distributions for post-test appeared almost similar and they meet all the criteria for a t-test. Table 2 shows the results of the independent T-test on the scores of post-test between experimental and the control groups.

Table 2: t-test comparison of post-test mean connection accuracy of the experimental and control groups

Variable	No. of trainees	Df	Mean	SD	t-value	Sig.(2-tailed)
Experimental Group	26	50	14.23	2.582	0.056^{ns}	0.956
Control Group	26		14.19	2.400		

ns: Not Significant level: 0.05

Source: Researcher, (2020)

From Table 2, the calculated t-value (t_{cal} = 0.056, df= 50, p = 0.956) was not significant at 0.05 alpha level. This implies that there is no significant difference between the Post-test (accuracy of connection test) mean scores in Physics of the virtual lab (VPL) and the Conventional Physics lab (CPL) trainees. This has the implication that virtual lab trainees gain the same accuracy in connection of the physical circuits the same way the non-virtual lab trainees gain the connection skills.

The trainees in the virtual-lab group scored a higher mean score in accuracy of connection than their non-virtual lab counterparts with a very small (negligible) effect size (Cohen's d = 0.02). The Cohen's d obtained here means that the result obtained in the post-test score in accuracy for the experimental group is 0.02 standard deviations from the mean of the control group.

4.2 Virtual laboratories in Skills Training-Speed of Connection

A t-test on pretest scores for speed of connection showed that the trainees in either group were equivalent before the treatment (116.56 minutes for experimental and 116.96 minutes for control; $t_{cal} = -0.470$, $df = 50$, $p = 0.641$). In order to do the t-test, the distributions of the connection time for the experimental and control groups at the post-test were checked. Table 3 shows the results of the independent T-test on the scores of post-tests between experimental and the control groups.

Table 3: t-test comparison of post-test mean connection times of the experimental and control groups

Variable	No. of trainees	Df	Mean time taken	SD	t-value	Sig.(2-tailed)
Experimental Group	26	50	106.46	5.132	-4.391*	
Control Group	26		112.38	4.579		0.000

*: Significant level: 0.05

Source: Field, (2020)

The calculated t-value ($t_{cal} = -4.391$, $df = 50$, $p = 0.000$) was significant at 0.05 alpha level. Therefore, the mean time of 106.46 minutes taken by the experimental group is significantly lower than the 112.38 minutes taken by the control group to accomplish connection of a set electrical circuit. In other words, the v-lab trainees took a remarkably shorter time to complete the connection of a set electrical circuit than their counterparts in the conventional Physics laboratory. The high Cohen's d = -1.22 means that the post-test connection time by the experimental group is -1.22 standard deviations below the mean time of the control group.

The transfer of training measures the percentage improvement between the virtual-lab and the no-virtual-lab group. The transfer in accuracy of connection was calculated as 0.28% while that of connection speed came to 5.27%. These means that for purposes of practical skills training, the v-labs should be used just as an additional or complementary activity to the physical laboratory experiments.

The study found out that virtual laboratory does not significantly improve the accuracy of connection of electrical circuits. This agrees with the results from several studies; the virtual laboratory enhancements the theory with the aid of giving a dynamic feel of the idealized system (Akpan & Strayer, 2010). Learners may incorrectly build up a mapping or model of the system that is unrealistic and their response to the real system might be inaccurate. The negligible influence of the v-labs on the accuracy of connection can be attributed to oversimplification of the laboratory tasks as designed in the software so the trainees do not get the commotion experienced with the actual physical situations of the real life. The trainees' accuracy of connection score was almost identical for the experimental and the control groups. Based on this the researches interpreted that the virtual laboratories giving trainees in either group an equal opportunity to learn connection of electrical circuit. In as far as accuracy of connection is concerned there is no difference in the effect of the laboratory in which one trained. Therefore, either virtual laboratory or the physical one may be used in instruction of connection of electrical and electronic circuits. The virtual labs were found to make trainees improve in speed of connection. This result agrees with that of Lampi (2013) who established that the student who practiced in the virtual laboratory did reduced their troubleshooting time of the computer networks. Again it agrees with the findings of Elliott et al. (2007) who established that fire fighters can gain skills in decision making via v-labs as well as indicating modifications in factors such as accuracy, speed, efficiency and planning. This conforms to the fact that the potential to rapidly arrange, disconnect and reconfigure circuits supposedly is a component in improving mistakes made by the trainees and aiming towards perfection in skills gaining according to Mayer and Johnson, (2010).

Therefore, the researchers find the v-labs to be superior to the physical labs in as far as the connection speeds is concerned. In other words they make the trainees who practiced in them take a shorter time to accomplish connection of physical equipment and components. This could because the trainees have a chance to go over the trials several times and they also form mind maps of the connections and again a high confidence about the connections. However, the v-labs don not significantly influence the accuracy of connection of physical circuits. This could be attributed to the fact that the trainees use the simulations which are oversimplified in the v-labs which is not transferred to the real world.

5. Conclusion and Recommendations

5.1 Conclusion

Based on the findings of the study, it can be inferred that the use of virtual Physics laboratory produced no superior results than those of conventional Physics laboratory as far as connection accuracy is concerned. However, practicing connection of electrical circuits in virtual Physics laboratory appreciably reduced time of connection of circuits in the real lab. This implies that the v-lab trainees were able to interpret the set circuit faster and connect it compared to the non-virtual lab group. Basing on these findings the utilization of virtual labs as a teaching tool in electrical and electronic circuitry is justified. The use of the v-labs is seen to have some contribution in the learning and practising skills. In conclusion, the investment in the development and usage of virtual labs in the training of trainees in electrical and electronic circuitry or related areas is worthwhile provided it meets the pedagogical threshold of authenticity of learning. The results of this study will add to the current body of knowledge the influence of v-labs on the teaching and getting to learn Physics at the tertiary level of education. Using this knowledge, the trainers of Physics and Physics related subjects, trainers of science and technology may additionally be able to maximize the benefits of the use of the Physics virtual laboratories as a learning and teaching resource.

5.2 Recommendations

The recommendations that follow are made based on the results, discussions and conclusions emanating from this study:

1. TVET trainers should afford their trainees opportunities to engage in meaningful learning activities through the use of v-labs in Physics so as to promote constructivism in the trainees.
2. There is need by the Ministry of Education, Science, Technology and Innovation through its Semi-Autonomous Government Agencies (SAGAs) such as TIVETA, KICD, KNEC, and other stakeholders to organize workshops on the use of v-labs to enhance better learning in TVET.
3. Kenyan teacher training should be improved so as to prepare teachers who can use v-labs.
4. The instructional designers, computer programmers, material developers should develop relevant virtual laboratories for use within the Kenyan TVET institutions
5. Virtual labs can be used to allow TVET trainees in developing nations where materials and equipment are not easily available or inadequate to experimenting and practicing in sciences.
6. Distance education learners who are enrolled in technical education can use v-labs to learn how to do task before the hands-on activities with real equipment. This could assist the trainees in reducing cost of staying on-site or travelling and time of being away from the workplace.
7. Trainees can fail in a safe environment where they cannot be involved in accidents that could be either electrical shock or even incidences of fire.
8. By practicing in virtual lab the time required in connecting the real circuits thereafter reduces.
9. A virtual lab of high fidelity can be used to train practical skills - transfer of skills between the virtual lab and the real lab if the virtual lab is well designed.

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