Acceptance and effectiveness of virtual patient cases for medical education in Zambia, Africa: A randomised controlled trial

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Abstract (max.: 300, currently: 298)

Background

In response to a significant shortage of health care providers in Zambia, particularly in rural regions, Chainama College of Health Sciences in Lusaka developed the Medical Licentiate program in 2002. The purpose of the program was to solve the human resource deficit in rural health-care facilities. In 2018, as part of a previous effort to address the issues of a shortage of medical instructors, an eLearning platform was established. Despite the fact that the platform was regarded to be an excellent learning tool, it was discovered that there were few interactive learning resources.

Objective

The aim was the assessment of virtual patient cases as a learning tool for Medical Licentiate students to address the lack of interactive learning resources available on the eLearning platform.

Methods

The effectiveness and perceived usefulness of virtual patient cases as a learning resource was evaluated in a mixed method approach. Methods included a questionnaire based on the Davis et al. 1989`s Technology Acceptance Model as well as a prospective, single-blinded, monocentric, and interventional randomised controlled trial. Outcome measures included gained knowledge and skills, usage, efficiency, acceptance, and user-friendliness.

Results

The examination included 69 students from the third and fourth years of the Medical Licentiate program. In comparison to other common learning materials, the virtual patient cases were found to have no significant increase in perceived usefulness and acceptance.

There was also no discernible difference in knowledge increase across the various intervention groups.

Conclusions

The first examination of virtual patient cases as a novel learning resource to be integrated into the eLearning platform found that they are equivalent to other common learning resources in terms of knowledge gain. VP cases thus have the potential to be a good interactive learning tool, but their acceptance rate as well as perceived usefulness must be improved.

1. Introduction: 492 (should be between 400-500)

1.1. Background:

Zambia, like other Sub-Saharan African nations, has a significant shortage of health care workers (HCWs), which has an influence on a number of public health issues, including disease treatment timeliness and quality, child mortality, and maternal health (1). This is particularly alarming in rural areas, where there are only seven doctors per 10,000 people, compared to sixteen in urban ones (2). This emphasizes the significance of increasing the number of HCWs, especially in rural regions, in order to fulfill the third Sustainable Development Goal: good health and well-being (3). The Zambian Ministry of Health created the medical licentiate practitioner (MLP) program at Chainama College of Health Sciences (CCHS) in Lusaka in 2002 to solve this issue. (4). CCHS has been a part of Levy Mwanawasa Medical University (LMMU) since 2019. The MLP program has become a four-year bachelor's degree program in clinical sciences (BSc CS) in 2017 (5). The first two years are mostly focused on theory, while the next two years are devoted to clinical internships (4). Throughout their internships, students rotate between numerous provincial and district hospitals in Zambia to gain valuable clinical experience. This will qualify them for a position in rural areas, where they will be responsible for administering provincial or district health institutions (6–8). Gajewski et al. observed in a 2017 study that MLPs are a major part of the professional health care workforce, particularly at rural district hospitals, performing emergency surgeries, C-sections, and prescribing medications (5). However, a scarcity of senior

medical professors, as well as infrastructural constraints such as limited training facilities and learning materials, make MLP program students' training difficult (9).

1.2. Virtual patients as digital, interactive mean to strengthen medical training

This research is part of the Blended Learning in Zambia (BliZ) initiative, a collaboration between the LMMU, the Heidelberg Institute of Global Health (HIGH), and the SolidarMed partner institution. The first BliZ-Project pilot phase evaluated the implementation of an eLearning platform for MLP-Students and revealed a high level of student and lecturer acceptance, as well as general enjoyment of the platform. However, there was a lack of learning materials and a need for more interactive learning materials (9). Virtual patient (VP) cases may be a beneficial tool for MLP students to bridge the gap between more interactive learning material and a better understanding of the clinical reasoning process.

The American Association of Medical Colleges' definition of VPs is often referenced to and says that VPs are “A specific type of computer-based program that simulates real-life clinical scenarios; learners emulate the roles of health care providers to obtain a history, conduct a physical exam, and make diagnostic and therapeutic decisions” (10).

This research aims to answers two questions:

1. Are VP cases an effective learning tool for knowledge acquisition and clinical reasoning process in comparison to other frequently used materials?
2. How is the acceptance of the VP cases by the MLPs in comparison to the other learning resources?

2. Methods 887 (should be between 700-800)

The CONSORT (Consolidated Standards of Reporting Trials) checklist was used to report this study (11). We conducted a prospective, single-blinded, monocentric, interventional randomized controlled study to assess the effectiveness of virtual patients (RCT; see Figure 1 for overview of RCT). On January 27, 2022, the RCT was registered with the Pan African Clinical Trials Registry.

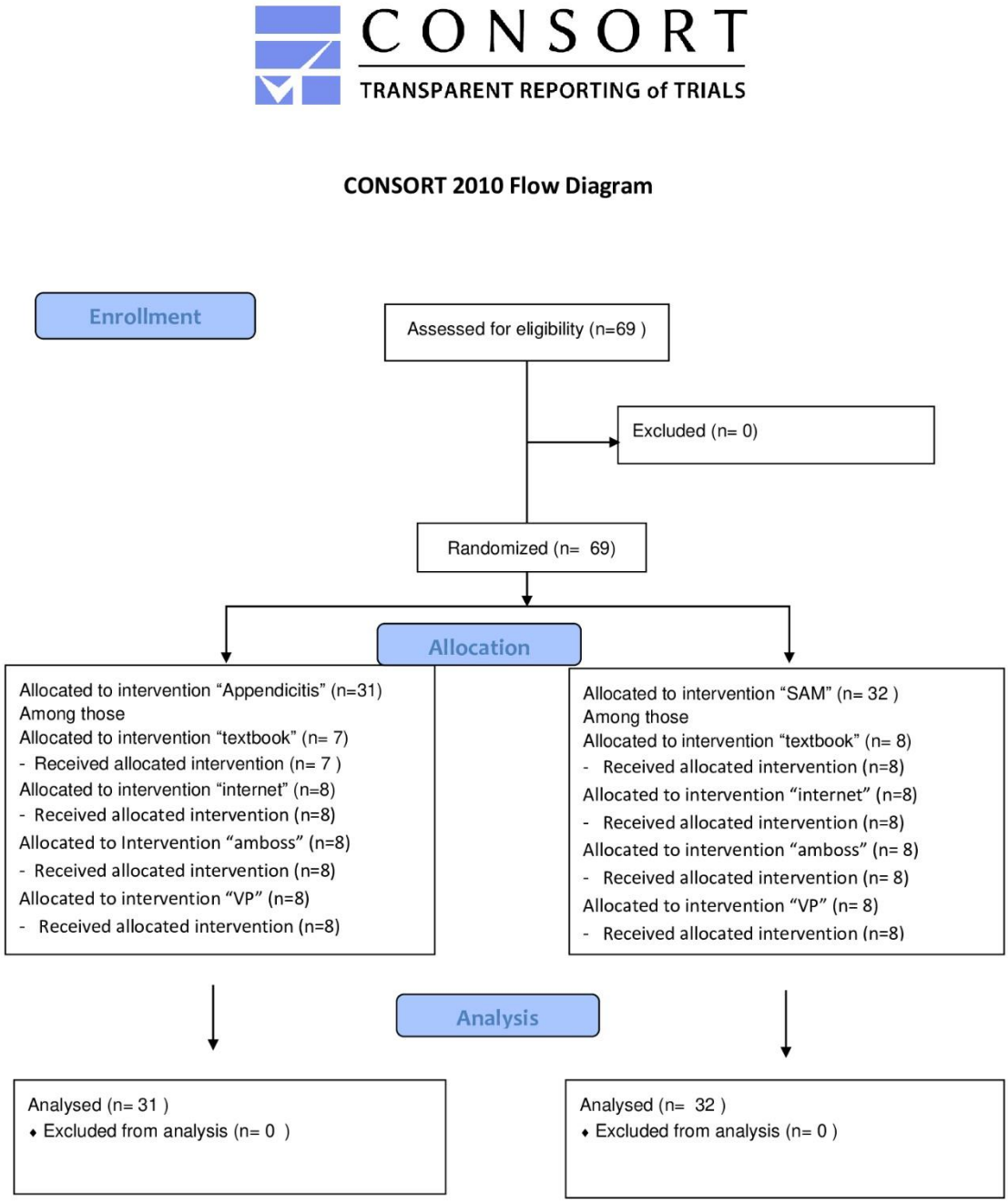

figure 1: Overview of randomized controlled trial according to CONSORT (11).

2.1. Randomisation, blinding and implementation

The recruitment of study participants began on November 29, 2021 using WhatsApp, email, and the local University administration. All third- and fourth-year BSc CS students above the age of 18 were asked to participate. A total of 63 students attended.

The names of participants were coded with an ID and the analytic team was absent to ensure single-blinding of the trial. Students completed a questionnaire assessing their age, gender, and year of study. The study personnel then divided the participants into two study arms based on two medical scenarios: (i) severe acute malnutrition (SAM) and (ii) appendicitis.

Following that, study participants were randomly assigned to one of four learning materials based on their current academic year, which served as a measure for their past medical expertise. The learning materials where:

(i) textbook pages of recommended books from the BSc CS curriculum:
   a. SAM: Nelson's Textbook of Pediatrics, 21st Edition, pages 336 – 352 (12)
   b. appendicitis: Bailey and Love's short practice of surgery, 27th edition, pages 1300 – 1317 (13)

(ii) free internet research

(iii) the e-learning platform AMBOSS (14)

(iv) our self-developed VP cases using iSpring incorporating materials from:
   a. SAM: World Health Organization (WHO) country guidelines (15), internet data (16,17), as well as from Nelsons's textbook (12)
   b. appendicitis: AMBOSS platform, respectively the website on appendictis (18)

All materials included information about the topics in equal measure. The VP cases were posted to LMMU's Moodle e-learning platform, but they were hidden and only available to participants on the trial day.

Each of the four groups received a pre-test consisting of content-based multiple-choice questions (MCQs). After that, the groups got 30 minutes of access to their learning material. The groups then took the MCQs again. In addition, each study participant was asked to fill out a questionnaire evaluating their satisfaction with the specific learning material. The research was conducted on December 10, 2021, at the LMMU main campus in Lusaka, Zambia.

2.2. Data collection

2.2.1. MCQ tests

The MCQ tests were used to measure the objective effectiveness of the different learning resources in terms of knowledge acquisition. The appendicitis MCQ test consisted of 20 questions (maximum score: 1000 points), while SAM had 15 questions (maximum score: 720 points). Each question had only one correct answer, and questions were the same for all groups. It was ensured that they were answerable using the available learning resources.

2.2.2. Acceptance questionnaire

The subjectively perceived usefulness of the distinct learning resources was determined using a questionnaire based on Davis et al. 1989's Technology Acceptance Model (TAM). The TAM has five dimensions: perceived usefulness, perceived ease of use, attitude towards using and behavioral intention to use. The fifth component (actual system use) was omitted from this questionnaire as it is unrelated to the subject of our research (19).

We added two new variables (job relevance and perceived enjoyment), based on Saloum et al. (20). The acceptance questionnaire consisted of fifteen questions, all of which were scored on a 5-point Likert scale (strongly disagree to strongly agree).

2.3. Data analysis

For all analyses, p-values less than 0.05 were considered significant and data was checked for normal distribution. Furthermore, both study arms (SAM and appendicitis) were pooled and then analyzed independently. To investigate the distribution of age, gender, and prior medical knowledge within the groups, descriptive statistics such as frequency, percentage, mean, median, and standard deviation were utilized.

The pre- and post-test results were analyzed in three distinct ways interpreting the data as a metric variable:

1) We used an analysis of variance (ANOVA) followed by a paired t-test with Bonferroni correction as a post-hoc testing strategy to see if there were any variations in previous knowledge across the four study groups of each study arm.
2) We used the same approach as in 1) to see if there was a variation in knowledge levels across the groups after exposure to different learning resources.
3) We utilized a Wilcoxon rank test in all four groups except the VP group, where the data was normally distributed and a t-test was used, to see if there was any significant difference in knowledge acquisition when comparing pre- and post-tests.

The 5-point Likert scale was was converted to numerical values (1 = "strongly agree" – 5 = "strongly disagree"). Using descriptive statistics, the distribution of satisfaction across

different categories was investigated. Then, the Kruskal-Wallis test was used to see if there was a statistically significant difference in the acceptability of the different learning resources among the four groups, followed by Wilcoxon rank tests with Bonferroni correction as a post hoc analysis.

2.4. Ethical considerations

The study received approval from the Heidelberg University Hospital Ethical Committee on August 30, 2021; #S-685/2021, and the LMMU Research Ethics Committee on November 29, 2021. The scope and objectives of the study, as well as their freedom to withdraw at any time, were explained to all study participants who were approached and selected. Each study participant signed a consent form and was treated with an ethic of respect.

3. Results 669

3.1. Demographics

The study participants had an average age of 39.56 years (±6.05). The youngest was 22 years old, and the oldest was 46. Males (n=39) outnumbered females (n=23) in the study. One person described himself as diverse. 32 of the 63 study participants were third-year students, while 31 were fourth-year students. (see Table 1)

Table 1: Overview of study arms composition and demographic characteristics.

Study arm 1 - Severe Acute Malnutrition (n=32)			
Intervention group	Number (%)	Average age	Gender
1 *virtual patient group*	25	29,38 (±1,77)	4 females 4 males
2 *textbook group*	25	27 (±5.04)	3 females 5 males
3 *AMBOSS group*	25	30,38 (±6,82)	4 females

(distinct learning resource: AMBOSS)			3 males 1 diverse
4 *internet group* (distinct learning resource: general research through internet access)	25	32,75 (±9,66)	8 males
Study arm 2 - Medical topic: Appendicitis (n=31)			
Intervention group	Number (%)	Average age	Gender
1 *virtual patient group*	25,8	29,39 (±4,57)	5 females 3 males
2 *textbook group*	22,6	29,17 (±3,87)	2 females 5 males
3 *AMBOSS group* (distinct learning resource: AMBOSS)	25,8	33,75 (±4,74)	1 females 7 males
4 *internet group* (distinct learning resource: general research through internet access)	25,8	32,28 (±7.51)	4 females 4 males

3.2. MCQ pre- and post-tests

3.2.1. SAM

The pre-test revealed a significant difference in knowledge between the *VP group* and the *textbook group* participants (p = 0.017), as well as a difference between the *VP group* and *internet group* (p = 0.05). Participants in the *VP group* received the highest results in the pre-test, with a mean of 67.67 % (score of 456, ±67.88) correctly answered questions, closely followed by those in the *AMBOSS group*, who correctly answered 63.33 % of the questions (score of 456, ±67.88). Students in the *internet group* scored 50 % (score of 360, ±105.79), while students in the *textbook group* scored 47.50 % (score of 342, ±82.89). The post-test findings revealed that the significant knowledge gap between the groups had vanished. The *AMBOSS group* scored 67.5 % (score of 486, ±132.7), the *VP group* scored 79.17 % (score of 480, ±82.89), the *internet group* scored 59.17 % (score of 426, ±165.16), and the *textbook group* scored 59.17 % (score of 426, ±82.89).

According to each study participant's learning curve, there was no significant growth in knowledge in the *AMBOSS group* and in the *internet group*; however, we found significant increase in knowledge in the two groups of the *textbook group* (p = 0.01301)

and the *VP group* (p = 0.01301) (see Figure 2 for individual learning curves of study participants in the intervention groups of study arm 1).

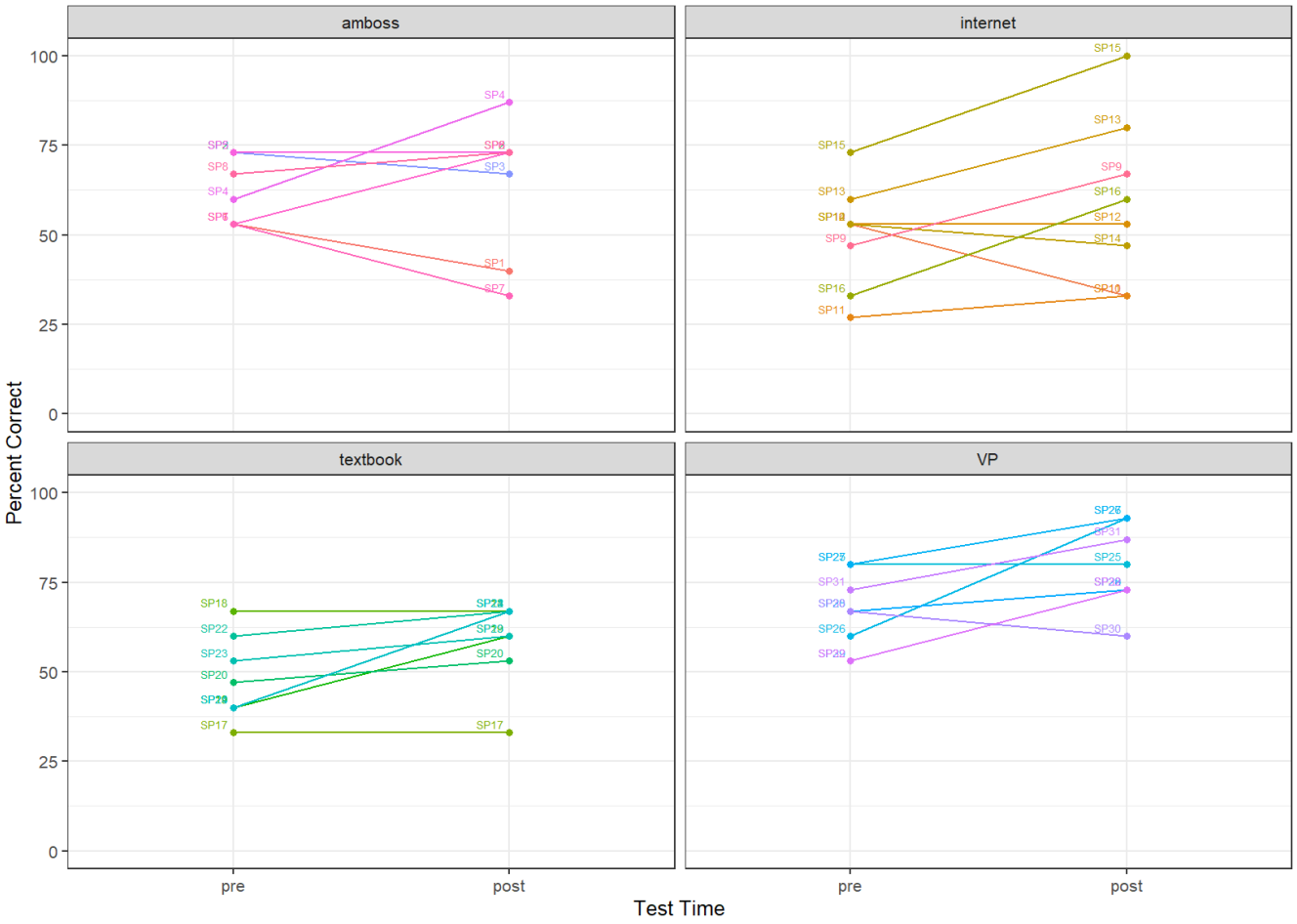

Figure 2: SAM: Individual learning curves of study participants (SP) separated by intervention groups showing the pre- and posttest results.

3.2.2. Appendicitis

The pre-test did not reveal a significant difference between the four intervention groups in the pretest. The participants in the *AMBOSS group* received the highest score in the pretest with a mean result of 75,00 % (score of 750p ± 46,29) closely followed by the participants in the *internet group* with 73,75 % (score of 735p ± 112,6) and the *textbook group* with 73,57% (score of 735 ± 146,3) and the *VP group* with a mean score of 71,87 % (score of 718 ± 106,7). There was a difference found between the intervention groups in

the post-test but it was not significant. The *AMBOSS group* had the highest score with a mean result of 88,75 % (score of 887,5 ± 74,4) followed by the *internet group* with a mean result of 85,0 % (score of 850 ± 75,59), the *textbook group* with a mean result of 82,14 % (score of 821,43 ± 128,64) and the *VP group* with a mean result of 80 % (score of 800 ± 128,17)

According to the individual learning curves there was an improvement in all four intervention groups, but not in a significant manner (see Figure 3 for individual learning curves of study participants in the intervention groups of study arm 2).

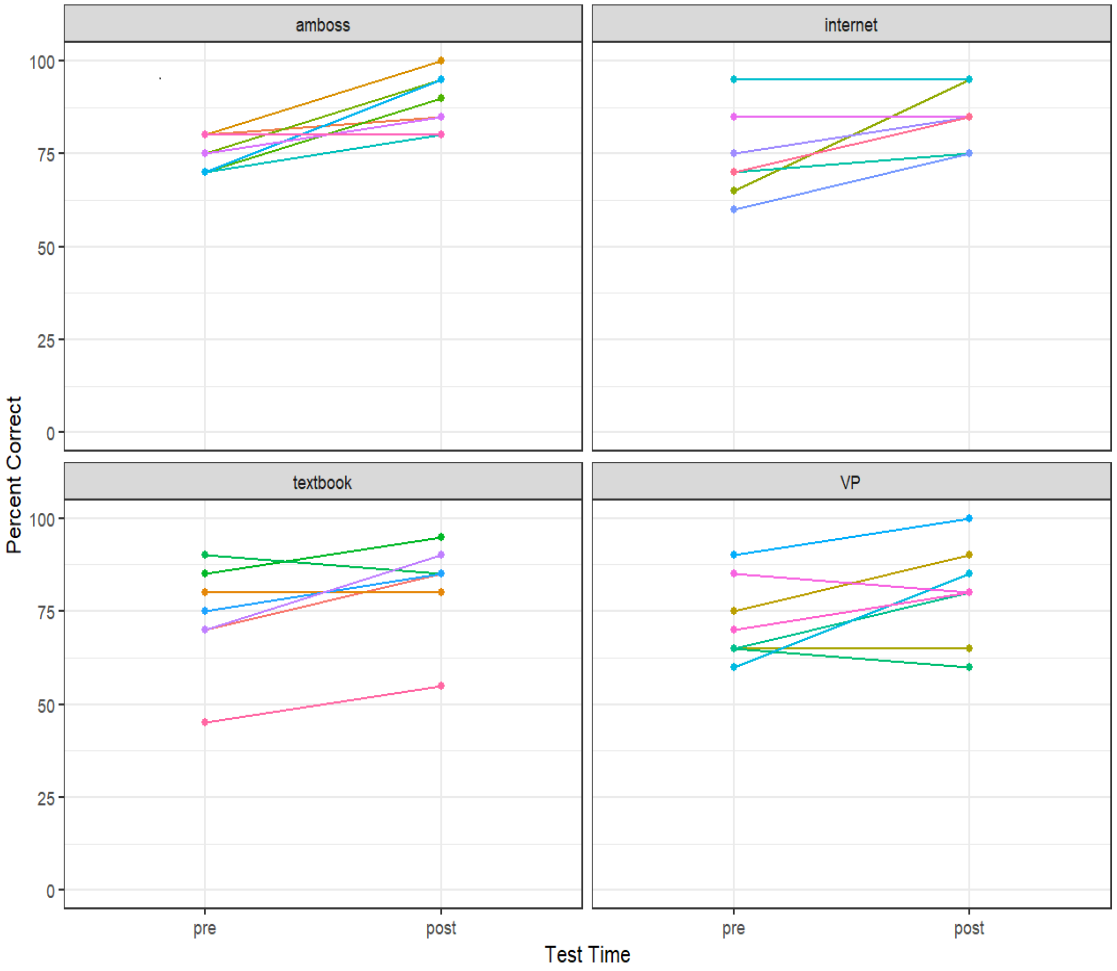

Figure 3 Appendicitis: Individual learning curves of study participants (SP) separated by intervention groups showing the pre- and posttest results.

3.3. Acceptance questionnaire

One question was omitted from the study since it was misunderstood by participants and was clearly identified as an outlier.

The question "If given the opportunity, I would favor this learning resource over others." revealed a significant difference for the topic SAM between the groups *AMBOSS* and *internet*. The *internet group's* mean rating (1.25, ±0.46) was greater than the *AMBOSS group's* mean (2.5, ±0.33) ($p = 0.013$).

There were significant differences in two questions on the questionnaire indicating acceptance of the learning approaches. For the statement “I think this learning resource is a good instrument to acquire knowledge.” a difference between the *AMBOSS* (mean: 1.5, ±0.53) and *internet group* (mean: 3.12, ±:1.13) with p = 0.029 was observed, whereby *AMBOSS* received more positive feedback than the *internet group*. On the statement “If given the opportunity I would favor this learning resource over others.” the mean response in the *AMBOSS* group was 1.38 (±0.52), which was considerably lower and thus better than in the *VP group* (mean: 3.62,: ±1.41) (p = 0.028). (see Table 2)

Table 2 results expressed as mean and standard deviation of the acceptance questionnaire of both study arms divided by the intervention groups

Study arm 1 - Severe Acute Malnutrition				
Questions from acceptance questionnaire	**Intervention groups: mean, standard deviation**			
	1 VP group	*2 textbook group*	*3 AMBOSS group*	*4 internet group*
If given the opportunity, I would favor this learning resource over others.	1.62, ±0.74	2.62, ±1.19	2.5, ±0.53	1.25, ±0.46
Study arm 2 - Medical topic: Appendicitis				
Question from acceptance questionnaire	**Intervention groups: mean, standard deviation**			
	1 VP group	*2 textbook group*	*3 AMBOSS group*	*4 internet group*
I think this learning resource is a good instrument to acquire knowledge.	*2.12*, ±0.64	*1.4*, ±0.89	1.5, ±0.53	3.12, ±:1.13
If given the opportunity I would favor this learning resource over others.	3.62,: ±1.41	*2*, ±0.82	1.38 ±0.52	*2.75*, ±1.04

4. Discussion 910

The goal of this study was to see if VPs as a learning tool are as successful as other commonly used learning methods and are also accepted by students of the B.Sc CS program.

4.1. MSC pre- and post-test

Despite the fact that the age and prior medical knowledge distributions were equal, the study arm 1 (SAM) pre-test revealed a significant difference between the *VP* and *textbook groups*. These differences could not be seen again in the post-test due to an increase in standard deviations, but changes in the mean were still clearly visible. Knowledge rose significantly in the *VP* and *textbook groups*, but not in the *AMBOSS* or *internet groups*. One cause could be that participants in the *AMBOSS* and *internet groups* had to actively search for answers, which could take longer than participants in the *VP* and *textbook groups*, who were given an excerpt to focus on. Looking at all of the participants, it was discovered that year four students improved more between the pre- and post-test in terms of who passed the tests. Tests were regarded passed if the overall score was greater than 50 %, which is the LMMU norm.

Surprisingly, some students did worse on the post-test than they had done on the pre-test. Delays in the study's completion owing to technological difficulties could be one reason. As a result, students had to wait and the study took longer than expected. This could have resulted in students unable to concentrate or rushing through the post-test. This phenomenon was also observed in study arm 2 (appendicitis). For this study arm the pretest revealed no significant differences between the subjects in the intervention groups. All four intervention groups showed an overall gain in knowledge, as seen by higher posttest scores.

4.2. Acceptance questionnaire

The questions examining the acceptance of various learning tools across six dimensions demonstrated comparability among all groups in both study arms. There was only one exception in the context of SAM. The *internet group* was determined to be the most inclined to favor their assigned learning resource over others with a significant difference to the *AMBOSS group*. Students had a neutral to slightly positive attitude toward this group, which had the worst mean rating of all the groups. This disparity between the *AMBOSS* and *internet groups* could be explained by the fact that students commonly utilize the internet to find answers quickly, yet many were inexperienced with using the *AMBOSS* database for research.

On the subject of appendicitis, participants had opposing views. They responded that *AMBOSS* is a good resource for acquiring knowledge, whereas participants in the *internet group* responded that they have a neutral opinion about it. Given that the *AMBOSS* pages are developed for usage in the United States, the appropriateness of the contents to the Zambian environment may be a factor explaining the variance in acceptability of *AMBOSS* as a learning resource between the two study arms. SAM is a more pressing issue in Zambia, and treatment may differ, whereas appendicitis is equally essential in both countries. The fact that participants in this intervention group were likely to prefer *AMBOSS* over other learning resources demonstrates *AMBOSS'* acceptance as a learning platform for the topic appendicitis. Students who worked on the SAM VP were more likely than those who worked on the appendicitis VP to prefer this learning material over others. The disparity could be due to the two VP cases' different designs. The SAM VP

has several illustrations and figures to aid comprehension and make the learning material more interesting, whereas the appendicitis example is more neutral. To confirm this assumption, an interview with the students would have been required.

It was conspicuous that many participants chose the same answer for all questions, and the reaction in general was very positive referring to all learning resources. A reason may again be the retardation on the study day especially since the acceptance questionnaire was the final component of the study.

4.3. Conclusion

The goal of this study was to see if VP cases are an effective learning tool for knowledge acquisition and clinical reasoning, as well as how well they are accepted, when compared to three other learning resources: internet research, commonly used books in the BSc CS program, and the e-learning platform AMBOSS.

When it came to efficacy and clinical reasoning, this study discovered no significant differences in knowledge acquisition, implying that VPs may be just as effective as other resources. More research is needed to verify this. There was a difference in the acceptability of the VP cases when the two study arms were compared. The SAM VP was accepted at a higher rate than the appendicitis case. Interviews with the participants would be required to assess whether the variance is due to the VPs' design or other reasons.

Furthermore, we discovered that the e-learning platform AMBOSS is better suited to appendicitis than SAM. To be a proper learning resource, AMBOSS may need to be adapted to the Zambian setting.

Our research has a number of limitations. It can only speak about students in years three and four of the BSc CS program. In addition, technological organizational challenges emerged, causing the study to be delayed on the study day. which could have influenced the results. Furthermore, the study did not investigate the long-term knowledge acquisition. Concluding , this study discovered that VPs could be a useful learning tool for BSC CS students, while more research is needed to improve VPs.

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