Indonesian Journal of Informatics Education

Research Paper

ISSN: 2549-0389

Comparing the Usability, Ergonomics, and Extensibility of Desknet Trainer and Netcube Trainer as Computer Network Learning Props in Vocational Education

Faizal Arifuddin
Educational Informatics and Computer Engineering
Faculty of Teacher Training and Education
Universitas Sebelas Maret
faizalarifuddin@gmail.com

Puspanda Hatta
Educational Informatics and Computer Engineering
Faculty of Teacher Training and Education
Universitas Sebelas Maret
hatta.puspanda@staff.uns.ac.id

Endar Suprih Wihidayat
Educational Informatics and Computer Engineering
Faculty of Teacher Training and Education
Universitas Sebelas Maret
endars@staff.uns.ac.id

Abstract:

The first objective of this study was to compare the usability, ergonomics, and extensibility of computer network learning props in vocational education. The second objective of this research is to obtain recommendations for developing a computer network trainer according to the weaknesses found in the comparison of usability, ergonomics, and extensibility. This research is quantitative research with a counterbalanced design. The study was carried out in two counterbalanced replications. The research subjects were 11 Informatics and Computer Engineering Education students at Universitas Sebelas Maret. The objects of this research are the Desknet Trainer and the Netcube Trainer. The data collection technique used is a questionnaire. The data analysis technique used is descriptive statistics and the T-test. The results showed that the comparison of Desknet Trainer and Netcube Trainer showed that the quality of both was statistically equivalent. The comparison breakdown of usability, ergonomics, and extensibility shows that the Desknet Trainer has weaknesses in the usability and ergonomics domains. In contrast, the Netcube Trainer has weaknesses in the extensibility domains. The Desknet Trainer can be further developed to improve usability and ergonomics. Netcube Trainer can be further developed to increase extensibility.

Keywords: Usability, Ergonomics, Extensibility, Learning Props, Vocational Education.

DOI: http://dx.doi.org/10.20961/ijie.v6i1.53901

Introduction

Learning media in the form of trainers or computer network learning props emerged as learning media innovations that positively impacted the implementation of computer network learning in vocational education. The learning outcomes of groups of learners who learned to use computer networking props (hardware) proved higher compared to the group of learners who learned to use computer network simulator media (software) in the form of Cisco Packet Tracer on the learning subject of Basic Data Communication and Computer Network (Bagaskara et al., 2019). The use of props in learning has also been shown to significantly improve student enthusiasm and activeness in the learning process (Uyun & Myori, 2021). Combined with some specific learning models, it also significantly increases student activeness and achievement (Umbarwati et al., 2017). Using these learning props has improved the learning outcomes in the cognitive, affective, and psychomotor domains. These benefits underlie the use of Desknet Trainer and Netcube Trainer in computer network learning.

The history of the Desknet Trainer and the Netcube Trainer occurred in the environment of Universitas Sebelas Maret in Indonesia. In 2016, a team at Universitas Sebelas Maret created a computer network prop called Desknet Trainer. This prop was created to handle basic computer network learning. Since then, this prop has been used by Universitas Sebelas Maret to improve their basic computer network courses.

Figure 1 shows the form of the Desknet Trainer. This prop has a table-like shape with a serving of computer network components in front of it. Desknet Trainer has specifications of Microtic Router RB-960, TP-Link TD8817 modem, D-Link DES-1008A 8 port switch, POE Ubiquity POE-24-24W-G, TP-Link TL-ANT2412D omnidirectional antenna, a monitor, and several examples of computer network cables and connectors. Desknet Trainer material is made of aluminum and iron plates. Desknet Trainer portability is supported using four small multi-directional wheels. The electrical power source for each component of the practicum is well organized.

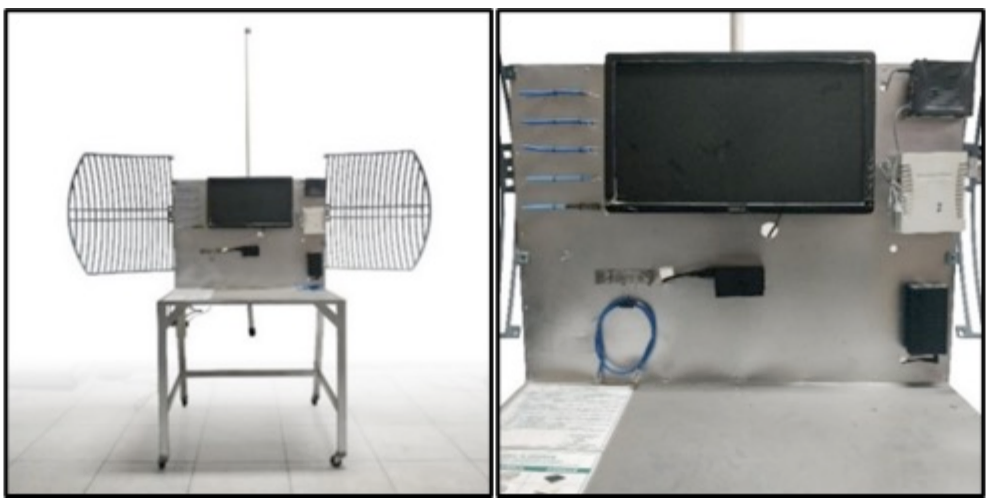

Figure 1. Desknet Trainer

Then in 2018, a new team at Universitas Sebelas Maret continued to develop a new computer network learning prop for another domain, namely advanced computer network learning. This learning prop is called the Netcube Trainer. Since then, this learning prop has been used by Universitas Sebelas Maret to handle advanced computer network learning.

Figure 2 shows the form of the Netcube Trainer. This prop has a cube shape in storage mode and the form of cube nets in learning mode. Netcube Trainer has four microtic RB-941 router specifications, DES-1008A 8 port D-Link switch, and several functional RJ-45 UTP cables. The prop material is made of wood. Netcube Trainer portability is supported by using the handle at the top. The electrical power source for each component of this prop is also well organized.

Figure 2. Netcube Trainer

However, in practice, it was found that Netcube Trainer can also be used to handle essential computer network learning. It can be a weakness for Desknet Trainer because this learning prop should be specifically designed for the basics of advanced computer network learning. It makes the quality of the two learning props in the realm of basic computer networks is being questioned. From the above case, three probabilities emerge: (1) The quality of the Desknet Trainer and Netcube Trainer is equivalent. This probability makes both learning props require improvement to reduce the weaknesses found. (2) The quality of the Desknet Trainer is still superior to the Netcube Trainer. This probability makes Desknet Trainer require less improvement. (3) The quality of Desknet Trainer is surpassed by Netcube Trainer. This probability makes Desknet Trainer require much modification.

A quality comparison is needed to find the answer to the above probabilities. Comparing the quality of the two learning props is the first objective of this study. This study defines the quality aspects by usability, ergonomics, and extensibility.

The second objective of this study is to obtain recommendations for developing a computer network trainer according to the weaknesses found in comparing usability, ergonomics, and extensibility.

Comparison Aspects

This section will explain the aspects used to compare the quality between the Desknet Trainer and the Netcube Trainer.

Usability

Usability is the ease with which users can learn to operate, prepare inputs, and interpret the output of a system component (Dubey, Rana, & Sharma, 2012). The usability mentioned above leads to the context of the software. Indeed, in research on usability, most of the objects studied are software, especially websites. Therefore, not all usability indicators are used in this study because this research is in hardware. Only those that match computer network props will be included.

In this study, aspects of usability used include effectiveness, efficiency, user satisfaction, ease of use, and learnability. Effectiveness, efficiency, and user satisfaction are taken from The international organization for standardization ISO 9241-11 (Perrier et al., 2022). Ease of use and learnability are taken from the Dubey literature review (Dubey, Rana, & Mridu, 2012). Some usability testing research also put ease of use as the main indicator of the testing instrument. It shows that the usability aspect can be customized based on the need (Alifah et al., 2019). These five aspects are considered appropriate to be used in the comparison between Desknet Trainer and Netcube Trainer.

Ergonomics

Ergonomics is a systematic branch of science to utilize information about the nature, ability, and limitations of humans in designing a working system, so that people can live and also work on a sound system that is to achieve the desired goal through practical, efficient, safe and comfortable work (Ginting, 2010). Other experts added that ergonomics is a "science" or multidisciplinary approach that aims to optimize the human-system work to achieve healthy, safe, comfortable, and efficient working tools and environment (Hutabarat, 2017). It shows that ergonomics has a solid relation to usability study. In the study of computer network props, the definition of ergonomics can be adapted into the study of the design of computer network props to help users work more efficiently.

Security and comfort are obtained from the MPRC indicator in Tullis and Stetson (2004), which is considered suitable as a comparative aspect of computer networking props. The word ergonomics is appropriate to summarize these two aspects because the safety and comfort of using props can make learning more efficient. It is also supported by Sujianto and Ramadhan, who says that safety and comfort are part of the principles of ergonomics (Sujianto & Ramadhan, 2022).

Extensibility

Extensibility measures a technology's capacity to add additional elements and features to an existing system (Kazman et al., 2022). In the realm of computer network learning props, the definition of extensibility is adjusted to make it easier for the props to adapt to changing specifications. Changes in specifications in question are differences in the specifications of the user's computer or laptop connected to the computer network props. Therefore, aspects of maintenance and upgradability found in Tullis & Stetson (2004) are included in an indicator called extensibility.

Research Method

The comparison method of computer network props was adopted from product usability comparison research. Choi and Li (2016) compared the usability of the text input method of several new remote types for smart TVs using the System Usability Scale (SUS). Smart TV text input and computer network props have in common as media. Seo and Kang (2019) also used the same method to compare smartphone game controllers. The technique used in the study above can also be used to compare the usability of computer network props with context adjustments.

The research method used is quantitative research. The design used in this study is counterbalanced. A counterbalanced design has the advantage of being able to rotate all differences that exist in groups (Ary et al., 2010). It means that if one group is superior to the other group, both props still get influenced by the advantage in a balanced manner. Similarly, if there are weaknesses and biases in one group, then both computer network props still get the influence of the fault and bias in a balanced manner as well.

The sample size used in this study was 11 participants. Sampling with a size of 11 participants followed the steps and suggestions of various relevant studies and literature (Brooke, 2013; Creswell, 2012). The sample size is considered representative of a comparative experimental study using a counterbalanced design (Choi & Li, 2016; Seo & Kang, 2019).

Data Collection

Data collection was carried out with an instrument in the form of a questionnaire. The instrument was adopted from SUS and MPRC.

SUS or System Usability Scale is a Likert scale questionnaire capable of providing a general measurement of usability in various contexts (Brooke, 2013). In the Likert scale questionnaire, respondents indicated agreement and disagreement with various statements about several attitudes, objects, subjects, or events. John Brooke developed this usability measurement instrument in 1986 with support from Digital Equipment Corp.

SUS items are shown below with the plus (+) sign indicating a positive item and the minus (-) sign indicating a negative item:

Table 1. SUS items

No.	Item	+/-
1	I want to use this system frequently.	+

2	I found the system unnecessarily complex.	-
3	I thought the system was easy to use.	+
4	I think I would need the support of a technical person to use this system.	-
5	I found the various function in this system were well integrated.	+
6	I thought there was too much inconsistency in this system.	-
7	I imagine most people would learn to use this system very quickly.	+
8	I found the system very cumbersome to use.	-
9	I felt very confident using the system.	+
10	I needed to learn many things before getting into this system.	-

Microsoft's Product Reaction Cards (MPRC) is an evaluation instrument that filters user perceptions of Microsoft products. Microsoft is a multinational technology company based in the United States. The company has become a technology development giant. The resulting product range is extensive, ranging from software to hardware. It makes MPRC valid for use in all product lines.

MPRC has 118 items. The items in the MPRC are positive and negative. The percentage of positive items is 60%, while the negative things are 40%. Positive and negative items are intended to avoid bias, and user responses will always produce positive results (Tullis & Stetson, 2004).

MPRC items are shown below with the plus (+) sign indicating a positive item and the minus (-) sign indicating a negative item:

Table 2. MPRC items

Accessible (+)	Desirable (+)	Gets in the way (+)	Patronizing (+)	Stressful (-)
Appealing (+)	Easy to use (+)	Hard to use (-)	Personal (+)	Time-consuming (-)
Attractive (+)	Efficient (+)	High Quality (+)	Predictable (+)	Time-saving (+)
Busy (-)	Empowering (+)	Inconsistent (-)	Relevant (+)	Too technical (-)
Collaborative (+)	Exciting (+)	Intimidating (-)	Reliable (+)	Trustworthy (+)
Complex (-)	Familiar (+)	Inviting (+)	Rigid (+)	Uncontrollable (-)
Comprehensive (+)	Fast (+)	Motivating (+)	Simplistic (+)	Unconventional (-)
Confusing (-)	Flexible (+)	Not Valuable (-)	Slow (-)	Unpredictable (-)
Connected (+)	Fresh (+)	Organized (+)	Sophisticated (+)	Usable (+)
Consistent (+)	Frustrating (-)	Overbearing (-)	Stimulating (+)	Useful (+)
Customizable (+)	Fun (+)	Overwhelming (-)	Straight forward (+)	Valuable (+)

Two experts in the relevant domain have validated the instrument used in this study. The first is a computer network expert at Universitas Sebelas Maret, and the second is a media expert at Universitas Sebelas Maret. This process eliminates many items that are less relevant to the comparison of learning props and leaves things that are relevant to this study. The results were in a questionnaire with 30 statement items, a combination of positive and negative articles written in Bahasa Indonesia. Each item received input in the form of a Likert scale of 5.

An assessment rubric is needed to change the ordinal data on the questionnaire into interval data. The rubric for scoring this instrument is the same as that used in SUS (Brooke, 1996). Positive items have a score range from 0 for disagreeing answers to a score of 4 for strongly agreeing on solutions. While the negative things have a score of 0 for strongly agree answers to 4 for disagree answers. The maximum possible score is 120 points. For the score to be in the range of 0-100 topics, the score will be divided by

120 and multiplied by 100. The score obtained does not have any meaning before being subjected to statistical operations (Brooke, 2013).

The questionnaire items are shown below with the plus (+) sign indicating a positive item and the minus (-) sign indicating a negative thing:

Table 3. Questionnaire items

Aspect	Sub-aspects	+/-	MPRC Item	No.
Usability	Effectivity	+	Collaborative	1
		-	Distracting	2
		+	Effective	3
		+	Helpful	4
		-	Ineffective	5
		+	Personal	6
		+	Useful	7
	Efficiency	+	Efficient	8
		+	Effortless	9
		-	Time Consuming	10
		+	Time-Saving	11
	User Satisfaction	+	Expected	12
		+	Satisfying	13
		-	Stressful	14
	Ease of Use	-	Difficult	15
		+	Easy to Use	16
		-	Frustrating	17
		-	Hard to Use	18
	Learnability	-	Complex	19
		+	Confident	20
		-	Confusing	21
		+	Predictable	22
		+	Understandable	23
		-	Unpredictable	24
Ergonomics	Security	-	Secure	25
	Comfort	+	Comfortable	26
Extensibility	Ease of Maintenance	-	Fragile	27
		+	Low Maintenance	28
				29
	Upgradability	+	Customizable	30

Procedure

The experiments in this study were conducted in two replications, as shown in figure 3. All participants will be divided into two groups. In the first replication, group 1 will perform a task 1 practicum using Desknet Trainer, and group 2 will perform a task 1 practicum using Netcube Trainer. After task 1 was completed, group 1 filled out a questionnaire for Desknet Trainer, and group 2 filled out a questionnaire for Netcube Trainer. In the second replication, group 2 performs task 2 practicum using Desknet Trainer, and group 1 performs task 2 practicum using Netcube Trainer. After task 2 was completed, group 2 filled out a questionnaire for Desknet Trainer, and group 1 filled out a questionnaire for Netcube Trainer. Thus, counterbalanced data is obtained.

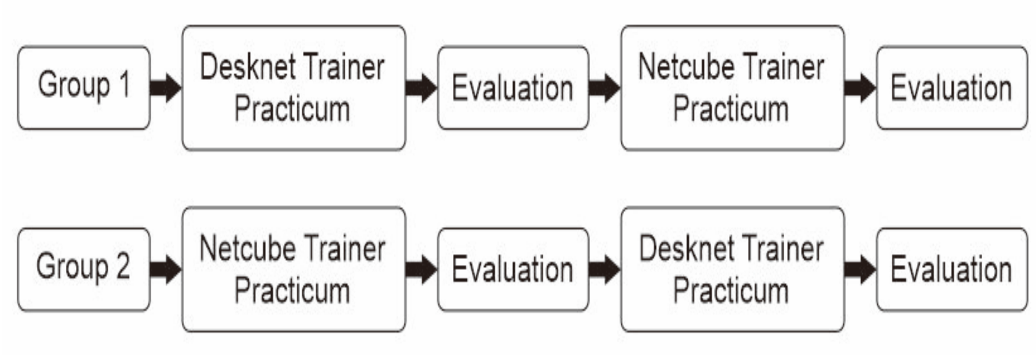

Figure 3. Experiment procedure of counterbalanced design

Result and Analysis

The following section presents the result of the experiment and analysis of the Desknet Trainer and Netcube Trainer scoring data.

Result

The research has produced data on scores for the Desknet Trainer and the Netcube Trainer. This section will discuss the description of the data and the processing of the data.

Table 4. Comparison of Desknet Trainer and Netcube Trainer scores

Learning Props	N	Mean	Std. Dev	Min	Max
Desknet Trainer	11	67.91	9.29	55	84
Netcube Trainer	11	71.37	7.70	62	89

Research respondents gave a higher value to the Netcube Trainer than the Desknet Trainer. The value obtained from the Netcube Trainer respondents is 62 – 89 (mean = 71.36), while the value obtained from the respondents for the Desknet Trainer is in the range of 55 – 84 (mean = 67.91). It shows that the Netcube Trainer, which is not designed for essential computer network learning, is even more preferred by students than the Desknet Trainer, designed explicitly for essential computer network learning.

Netcube Trainer has a lower minimum, maximum, and mean values than Desknet Trainer. Although there is a descriptive difference, it does not prove that Netcube Trainer is superior to Desknet Trainer. Doing a T-test is the provision that becomes the basis for determining which learning props is more prominent.

Table 5. Significance of Desknet Trainer and Netcube Trainer scores

Mean	Std. Dev	Std. Error Mean	t	df	Sig. (2-tailed)
-3.45	9.20	2.77	-1.24	10	0.24

The t-test with a significance level of = 0.05 shows a significance value (Sig. 2-tailed) of 0.24 and a t-value of 1.24. By seeing that the significance value is greater than the significance level (0.24 > 0.05) and the t-value is smaller than the t-table value (1.24 < 2.23), the results of the t-test are not significant enough. Thus, it can be said that there is no difference in quality in the aspects of usability, ergonomics, and extensibility of the Desknet Trainer and Netcube Trainer as learning media for computer networks in vocational education.

The following is a table of Desknet Trainer and Netcube Trainer scores separated by aspect:

Table 6. Average Desknet Trainer and Netcube Trainer scores for each aspect

Learning Props	Mean		
	Usability	Ergonomics	Extensibility
Desknet Trainer	68.84	67.04	61.94
Netcube Trainer	73.20	76.14	56.82

This data is used to determine the weak points of the two learning props. This data will determine which aspects of the computer network learning props need to be improved.

In the usability aspect, the average Desknet Trainer score is 68.84, while the Netcube Trainer usability score is 73.20. This difference shows that users find

In ergonomic aspects, the average Desknet Trainer score is 67.04, while the average ergonomic score of a Netcube Trainer is 76.14. This difference shows that users feel more secure and comfortable using a Netcube Trainer than Desknet Trainer.

In extensibility, the average score of Desknet Trainers is 61.94, while the average extensibility score of Netcube Trainers is 56.82. This difference shows that users find it easier to maintain and upgrade the Desknet Trainer than the Netcube Trainer.

Analysis

Finding 1: The quality of the Desknet Trainer and Netcube Trainer is equivalent.

The results of the study said that the Desknet Trainer and the Netcube Trainer have equal quality in terms of usability, ergonomics, and extensibility as computer network learning props in vocational education. There are several underlying reasons why this could happen.

The number of research objects is suspected of affecting the results using SUS as a research instrument. Choi and Li (2016) compared five different research objects with SUS. Twenty participants attended the study. Choi and Li (2016) obtained significant results with that number of participants.

In another study, Seo and Kang (2019) carried out four types of research objects. The study also produced significant results even though the number of participants in one group was nine people. This number is less than the number of participants in this study.

This assumption is reinforced by Fang and Lin (2019), who found that two of the three research objects compared proved to have no significant differences. Comparisons with Fang and Lin (2019) were also carried out using the modified SUS instrument according to the needs of the study. One research object that was compared proved to have a significant difference compared to the other two. So, if the number of learning props being reached is three or more, it is likely that considerable research results will be obtained.

Another factor that is suspected to affect the study results is the lack of standardization of computer network learning props specifically. The standard referred to in this discussion is the standard as a requirement (Ferreira et al., 2020). Without standardization, Desknet Trainer and Netcube Trainer do not have a direction for targeted prop development. Furthermore, developers do not know how far computer network props must be developed and tested to get computer network props categorized as sufficient, exemplary, or perfect.

The group investigation learning model has increased the effectiveness of using Virtual Box in some cases (Umbarwati et al., 2017). Compared to that, Desknet Trainer and Netcube Trainer do not have any specific learning model to be conducted in class. It has also been suspected the outcome of the research above could become a future improvement for the developers. Improve the learning props and the model explicitly designed for each learning prop.

Finding 2: Both learning props require improvement to reduce the weaknesses found.

Based on the items that have a low score on the effectiveness indicator, Desknet Trainer is still considered less effective in collaborative or group work, and the number of tools displayed on these props is considered to distract concentration during the learning process. It is recommended that Desknet Trainer developers expand the work area of support so that users can learn collaboratively or in groups effectively. In addition, tools that are not yet needed in certain practicums should be covered, as in Netcube Trainer, so that users can directly focus on what is being instructed to be learned. Thus, it is expected that the effectiveness of Desknet Trainer in handling computer network learning can increase.

Based on items with a low score on efficiency indicators, Desknet Trainer is considered to take longer and requires more effort than Netcube Trainer. So, it is recommended that desknet trainer developers improve the placement of practicum tools to make it easier to reach users. It can make learning preparation faster and does not require much effort. Thus, it is expected that the efficiency of Desknet Trainer in handling computer network learning can be increased.

Based on the items with a low score on the user satisfaction indicator, Desknet Trainer is considered less satisfactory than Netcube Trainer. No specific item on this indicator can indicate which parts need to be repaired. Improvements to the product's visual design are expected to improve desknet trainer user satisfaction.

Based on the items with a low score on the ease of use indicator, Desknet Trainer is considered easier to experience connection interference compared to Netcube Trainer. It is concerned with tools that require cables to connect to computer networks. So, it is recommended that the developer of Desknet Trainer improve the quality of computer network cables by replacing them with more flexible wires to make it easier for users to connect ports between computer network devices.

Based on the items with a low score on the learnability indicator, Desknet Trainer is considered more complex and confusing than Netcube Trainer. Therefore, it is recommended that Desknet Trainer developers label every computer network practicum tool loaded on the trainer. The label given can be the name and function of each tool. Color can be used to distinguish the use of tools needed on particular instructions. The use of several colors, such as those done in Desknet Trainer, is expected to maintain the user's focus on one type of instruction given. Thus, it is anticipated that Desknet Trainer users do not consider these props complex and confusing.

Based on items with a low score on security indicators, Desknet Trainer is still considered less secure compared to Netcube Trainer. The material used in the Desknet Trainer work area is metal, while the Netcube trainer work area material is wood. Users assume that the Netcube Trainer is safer in terms of electricity because wood is an insulator of electricity, while metal is a conductor of electrical flow. Then it is recommended that Desknet Trainer developers add a layer of electrical insulators to their work area. Thus, it is expected that the security of using Desknet Trainer can be increased.

Based on items with a low comfort indicator score, Desknet Trainer is still considered less comfortable than Netcube Trainer. The area of Desknet Trainer work area is limited to the dimensions of the tool, while the area of work Netcube Trainer is more flexible because it can be placed anywhere. In addition, the height of the work area also affects users' comfort. It is recommended that Desknet Trainer developers increase the area of work and add mechanisms so that the height of the work area can be adjusted to the physical needs of users. Thus, the comfort of using Desknet Trainer is expected to be increased.

Based on the items with a low score on the maintenance indicator, users felt that the effort required to maintain the Netcube Trainer was greater than that of the Desknet Trainer. The Netcube Trainer has a portable design that can carry where the user wants. The use of the Netcube Trainer produces more shocks to the computer network equipment than the use of the Desknet Trainer. It makes the Netcube Trainer has a more significant potential for damage than the Desknet Trainer. So, it is recommended that Netcube Trainer developers add shock absorbers to computer network tools. Thus, the effort required for Netcube Trainer maintenance can be reduced.

Based on the items with a low score on the upgrade indicator, users feel that the Netcube Trainer is more difficult to upgrade than the Desknet Trainer. It is related to the arrangement of tools and mechanisms of the Netcube Trainer, which is more compact and foldable. So, it is recommended that Netcube Trainer developers pay attention to the availability of upgrade sites for computer network tools. Thus, upgrading computer network tools on the Netcube Trainer can be done quickly.

Conclusion

Based on the results and analysis, the conclusions are obtained as follows:

1. Desknet Trainer and Netcube Trainer have equivalent quality in usability, ergonomics, and extensibility as primary computer network learning props in vocational education.
2. Desknet Trainer development recommendations are obtained on effectiveness, efficiency, user satisfaction, ease of use, ease of study, safety, and service comfort to improve usability and ergonomics. As for Netcube, Trainer obtained development recommendations on maintenance and upgraded aspects to enhance extensibility.

Suggestion

For further researchers, it is recommended to develop standardization of computer network learning props in basic and advanced computer network learning. It will be helpful for computer network learning props developers in maintaining quality.

Finding or designing the learning model for each learning prop is also recommended. This research can be continued to find the learning outcomes in the cognitive, affective, and psychomotor domains when the fit learning model is provided.

Deep evaluation kind of research is also possible in the future. Researchers can deeply evaluate each learning prop based on every aspect of usability, ergonomics, and extensibility separately.

References

Alifah, N., Wihidayat, E., & Sujana, Y. (2019). Feasibility Study of Web-Based Internship's Information System Based on ISO 1926 Standard. *Indonesian Journal of Informatics Education*, *3*(1), 1–10. https://doi.org/doi.org/10.20961/ijie.v3i1.12608

Ary, D., Jacobs, L. C., Sorensen, C., & Razavieh, A. (2010). *Introduction to Research in Education Eight Edition*. Cengage Learning.

Bagaskara, K., Efendi, A., & Hatta, P. (2019). Basic Computer Networking Trainer: How Does The Effectiveness Towards Learning Outcomes Improvements? *Journal of Informatics and Vocational Education*, *2*(3). https://doi.org/10.20961/joive.v2i3.37976

Brooke, J. (1996). SUS: A "Quick and Dirty" Usability Scale. In *Usability Evaluation In Industry* (pp. 207–212). CRC Press. https://doi.org/10.1201/9781498710411-35

Brooke, J. (2013). SUS: a retrospective. *Journal of Usability Studies*, *8*(2), 29–40. https://dl.acm.org/doi/10.5555/2817912.2817913

Choi, Y. M., & Li, J. (2016). Usability evaluation of a new text input method for smart TVs. *Journal of Usability Studies*, *11*(3), 110–123. https://dl.acm.org/doi/10.5555/2993219.2993222

Creswell, J. W. (2012). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research*. Pearson Education, Inc.

Dubey, S. K., Rana, A., & Mridu, M. (2012). Analytical Comparison of Usability Measurement Methods. *International Journal of Computer Applications*, *39*(15), 11–18. https://doi.org/10.5120/4895-7414

Dubey, S. K., Rana, A., & Sharma, A. (2012). Article: Usability Evaluation of Object Oriented Software System using Fuzzy Logic Approach. *International Journal of Computer Applications*, *43*(19), 1–6. https://doi.org/10.5120/6208-8778

Fang, Y.-M., & Lin, C. (2019). The usability testing of VR interface for tourism apps. *Applied Sciences*, *9*(16), 3215. https://doi.org/10.3390/app9163215

Ferreira, J. M., Acuña, S. T., Dieste, O., Vegas, S., Santos, A., Rodríguez, F., & Juristo, N. (2020). Impact of usability mechanisms: An experiment on efficiency, effectiveness and user satisfaction. *Information and Software Technology*, *117*(106195). https://doi.org/10.1016/j.infsof.2019.106195

Ginting, R. (2010). *Perancangan Produk, Edisi Pertama*. Graha Ilmu.

Hutabarat, J. (2017). *Dasar Dasar Pengetahuan Ergonomi*. Media Nusa Creative.

Kazman, R., Echeverría, S., & Ivers, J. (2022). *Extensibility*. Carnegie Mellon University. https://doi.org/10.1184/R1/18863639

Perrier, M. J. R., Louw, T. L., & Carsten, O. M. J. (2022). Usability testing of three visual HMIs for assisted driving: How design impacts driver distraction and mental models. *Ergonomics*, 1–22. https://doi.org/10.1080/00140139.2022.2136766

Seo, S.-D., & Kang, S. (2019). A Comparison Study of the Smartphone Gaming Control. *Journal of Usability Studies*, *14*(4). https://dl.acm.org/doi/10.5555/3542805.3542808

Sujianto, S., & Ramadhan, F. (2022). Perancangan Mesin Peniris Minyak untuk Kerupuk Bawang Menggunkan Kaidah Ergonomi. *Prosiding SENIATI*, *6*(4), 794–797. https://doi.org/10.36040/seniati.v6i4.5091

Tullis, T. S., & Stetson, J. N. (2004). A Comparison of Questionnaires for Assessing Website Usability. *Usability Professional Association Conference*, 1–12. https://www.researchgate.net/publication/228609327_A_Comparison_of_Questionnaires_for_Assessing_Website_Usability

Umbarwati, R., Basori, B., & Sucipto, T. (2017). The Influence of Group Investigation and Virtual Box Learning Media to Students' Activeness. *Indonesian Journal of Informatics Education*, *1*(1). https://doi.org/10.20961/ijie.v1i1.4150

Uyun, I., & Myori, D. E. (2021). Efektivitas Penerapan Trainer sebagai Media Pembelajaran Dasar Listrik Elektronika. *Jurnal Pendidikan Teknik Elektro*, *2*(1), 47–51. https://doi.org/10.24036/jpte.v2i1.65