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HistoGuide Mobile Application (Virtual Microscopy and Slides): A Quantitative Usability Pilot Study

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Abstract

HistoGuide application is a smartphone application system used by sixth-form students for virtual microscopy and slides to solve the problems of incorrect drawing and labelling, inability to apply magnification and scale, and inability to observe details in microscopic practical works. However, as a newly developed application, many still do not understand the usability of the HistoGuide application. In building a good application, one important part is good usability. Usability testing, especially in the HistoGuide application, can show users' ease and efficiency in using the system. The authors try using the USE questionnaire with 33 respondents as a pilot study before a real one. The analysis resulted in an average value of the usefulness construct of 92.8%. Then, the construct ease of use with 92.4%, ease of learning with 92.4%, and satisfaction with 93.8%. These results indicate that the HistoGuide application is good. The results of measuring the usability of the HistoGuide application with the classification "High" to use, with a usability value of 92.8%. The results of usability measurement are expected to help develop and improve the HistoGuide application in the future to complement the conventional microscopic practicals works.

Keywords: HistoGuide application, virtual microscopy and slides, usability, USE questionnaire

INTRODUCTION

During the Covid-19 pandemic, schools shifted to online teaching, which is also true in the case of Malaysia. Educators employed various teaching methods, including virtual microscopy, especially during the lockdown in replacement of laboratory work. However, during post-pandemic, these practices have continued. Thus, the students' manipulative skills (dexterity) acquirement has been an issue when it comes to laboratory work (Muhammad Mushfi El Iq Bali & Musrifah, 2020).

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A comprehensive guideline is necessary to guide students in executing biology microscopic practicals in sixth-form education (STPM/pre-university). Hence, a guide application is essential to help students draw and label precisely, besides applying magnification and scale, bearing in mind the usefulness, ease of use, ease of learning and satisfaction of the application cause to the students. Besides improving the school-based assessment, the guide application usage is hoped to increase student's confidence level and motivation in executing the microscopic practicals. However, there is a lack of comprehensive guidelines for after-secondary education in Malaysia. Hence, a new mobile application that caters to the needs is developed and proposed, as in the HistoGuide application (virtual microscopy and slides).

Most researchers recommend using virtual microscopy and slides, and the usage has been proven successful (Blake et al., 2003; Heidger et al., 2002; Pospíšilová et al., 2013; Romero et al., 2007). Then, more educators have moved to a computer-based virtual learning approach to histology teaching to save time, money and laboratory space (Braun & Kearns, 2008). However, many educators have emphasized using microscopes and glass slides to learn histology properly. The ideal or optimal alternative in histology teaching would be an active learning approach (Michael, 2006) that melds microscope-based learning strategy with computer-based learning tools (Harris et al., 2001; Heidger et al., 2002; Pratt, 2009). Previously, Jonas-Dwyer et al. (2007) mentioned that students use virtual microscopy as self-directed learning. Students must be prepared for the microscopic laboratory practical to have effective learning. There have been many studies done on virtual microscopy and slides previously.

However, due to many limitations and lack of understanding or inconclusive research, studies on virtual microscopy are still ongoing. A systematic literature review has been carried out only on studies from 2010 onwards. Amer and Nemenqani (2020) mentioned that the validity and reliability of online assessment for performance using virtual microscopy is a concern since their study was done during the Covid-19 pandemic. Meanwhile, in their study, Lee et al. (2020) over or underestimated the association between virtual microscopy and academic performance.

LITERATURE REVIEW

Preliminary findings from one of the sixth-form centres in Kuala Lumpur showed that 68.8% of students scored below five in the results section of the school-based assessment. Drawing, labelling, and applying magnification and scales encompass about 40.0% of the marks allocated in the single assessment, which consisted of manipulative skills (A), results (B), discussion (C), and conclusion (D). Students are found to be weak in drawing, labelling and applying magnification and scales. Drawing and labelling aspects must be fulfilled together to acquire the allocated marks. Only 9.4% of students scored full marks in the results section (B), emphasizing drawing and labelling. The findings were supported by Cheung and Winterbottom (2021), which explored students' visualization competence and found that they are weak in perceiving microscopic entities through drawing and labelling. They reported that 60.0% of the students could not label their biological drawings, and a higher proportion of students tend to give fewer labels (Cheung & Winterbottom, 2021)

The incorrect drawings, labelling or both are identified as the observable symptoms of the problem. Hoese and Casem (2007) mentioned that teachers could gather large amounts of data on students' mental models of scientific concepts using microscopic drawings. The drawings determine conceptual understanding and misconceptions (Köse, 2008). Drawing exposes misconceptions (Quillin & Thomas, 2015). The researchers gave samples of references that reveal misconceptions through drawings. These incorrect drawings and labelling or both will decrease the school-based assessment and students' motivation to execute practicals, as shown in Figure 2.1. It is due to the inability of students to draw and label, apply magnification and scale and observe details as there is a lack of quality images for practicals (García et al., 2019).

Thus, from the literature review of selected studies in histology, it can be concluded that virtual microscopy and slides address the mentioned students' inabilities, as suggested by Alegre-Martínez et al. (2016). Hence, a mobile application is proposed to address the problems/issues. Students are constantly looking to employ digital technology in their learning (Bajt, 2011). Students wanted dynamic, participatory, and meaningful learning incorporating observation and practice (Shatto & Erwin, 2016). The technology employed has usability constructs of usefulness, ease of use, ease of learning, and satisfaction, as Lund (2001) suggested. The HistoGuide application will be tested through usability testing.

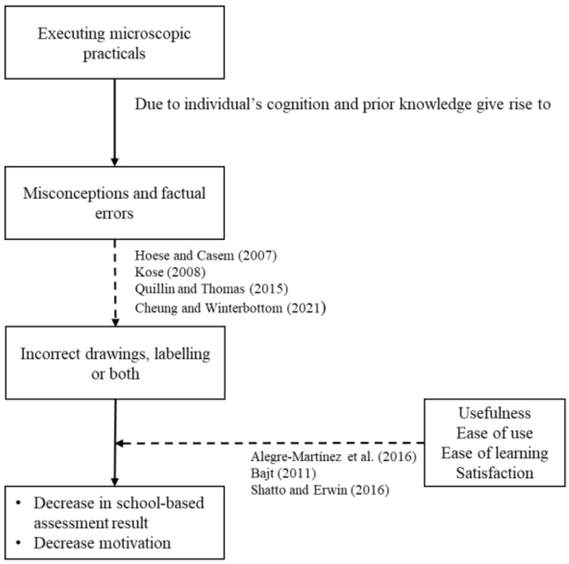

Figure 1: Symptoms/issues arise during the execution of microscopic practicals

Usability questionnaires are used to obtain self-reported data from users about their interactions with a particular product or system. The usefulness, satisfaction, and ease of use (USE) questionnaire by Lund (2001) measure a product's or service's subjective usability. Items in the USE questionnaire also

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have strong face validity, with clear and relevant descriptions. However, little published research has reported the USE's reliability or validity. Because it is non-proprietary, this instrument can be applied to various usability assessment scenarios. The lack of reliability and validity makes researchers hesitant to use the USE questionnaire. Hence, the items underwent a complete psychometric instrument development process to develop a standardized instrument (Gao et al., 2018). By using the USE questionnaire, Hariyanto et al. (2020) revealed in their research that the adaptive e-learning system's usability for students was initially well-approved in all dimensions of usability.

Usability testing refers to testing the usability of the HistoGuide application through four constructs; usefulness, ease of use, ease of learning and satisfaction. The usability testing uses the survey method by distributing survey instruments to the samples. The survey has 30 items from the USE questionnaire (Lund, 2001), adapted from Hariyanto et al. (2020). The data is analyzed to gauge the usability of the Histoguide application.

METHODOLOGY

The research is a quantitative study. The research applied developmental research design and survey design. The developmental design involved the design and development of the HistoGuide application based on the ADDIE model. It was designed and developed, and its impacts were evaluated regarding usability in microscopic practicals. Experts validated the HistoGuide application in content, pedagogical, and technology aspects. The sample of the HistoGuide application is illustrated in Figure 2. At the same time, the procedure of the studies is outlined in Figure 3.

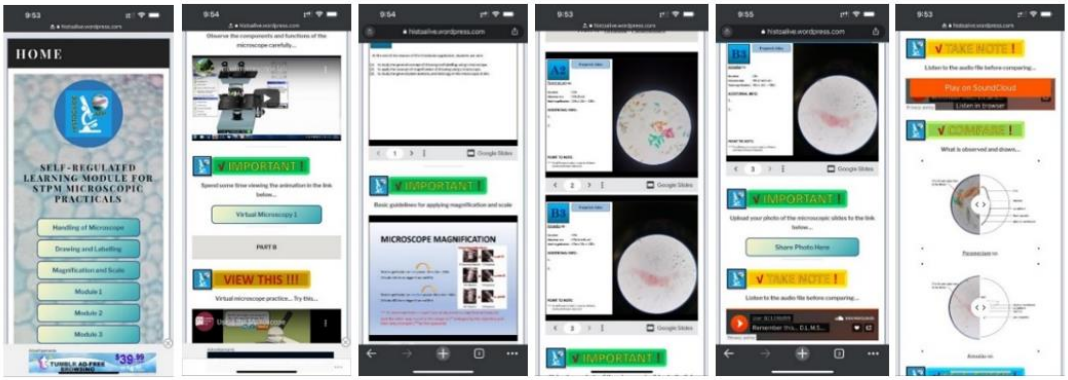

Figure 2: Screenshots of the HistoGuide application

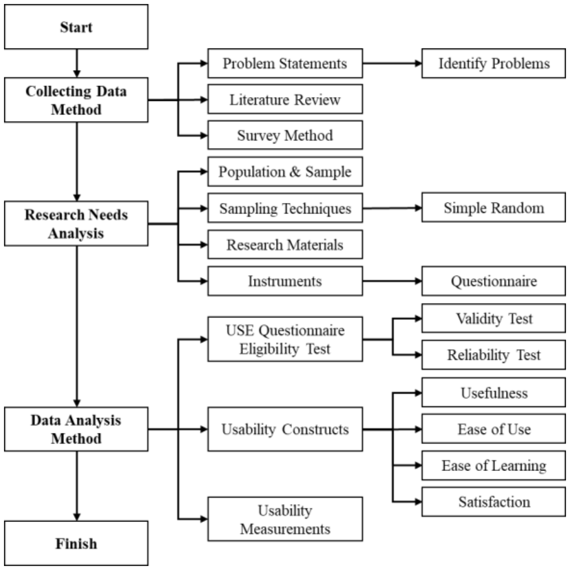

Figure 3: Procedure of the study

Ideally, it is best to study the entire population. However, it is unfeasible to do this, so a sample must be taken. Selecting samples or responders from a population is sampling (L. Cohen et al., 2018). The questionnaire survey will be used to collect the data for studying usability. For this study, simple random probability sampling is selected. The number of students taking biology in STPM is about 1900. Hence, according to Krejcie and Morgan (1970), the population size is about 1900, and the ideal sample size should be more than 320 for the study. In general, the sample size is closest to the real population size to prevent biases in sampling (Krejcie & Morgan, 1970). But, since the research is conducted in schools in Penang, Malaysia, the population is about 180 taking biology in sixth-form. The study's ideal sample size should be more than 123 (Ghazali Darusalam & Sufean Hussin, 2016). Penang was chosen because it resembles the national demographic of students, consisting of rural and urban schools. Besides that, they have all three modes of sixth-form centres. The implementation of the HistoGuide application involved a pilot test that involved user testing. A pilot test, a reduced-scale study, was conducted before the actual research. The pilot test was conducted in a sixth-form centre, with the same characteristics as the real sample but from a different state. Hence, 33 samples were acquired for this pilot study in Kuala Lumpur.

In the survey design, the questionnaire technique was employed. Lund (2001) proposed utilizing the USE questionnaire to test for usability. USE stands for Usefulness, Satisfaction, and Ease of use. Ideally, it is employed for software, hardware services, and user support materials development. It treats the dimension of usability as a dependent variable. USE questionnaire consisted of 30 items in four constructs; usefulness, ease of use, ease of learning, and satisfaction. Data analysis procedures in the study are in Table 1.

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Table 1: Data analysis procedure

Research Questions	Instruments	Data analysis
What is the level of usability of the HistoGuide application? a) Usefulness? b) Ease of use? c) Ease of learning? d) Satisfaction?	USE questionnaire	Percentage and mean/average value

In the study for usability, variables in terms of percentage, average value or mean were used. The mean score can be deciphered using a cut-off point (Hamidah Yusof et al., 2015). The Interval scale of the mean score is calculated before the levels in the mean score are determined. The formula is as given: Interval scale of mean score = $\frac{highest\ value - lowest\ value}{number\ of\ class\ interval} = \frac{5-1}{3} = 1.33$

Based on the calculation above, the levels in the mean score are shown in Table 2

Table 2: Levels in the mean score for usability determination

Mean score	Mean score level
3.68 – 5.00	High
2.34 – 3.67	Moderate
1.00 – 2.33	Low

Source: Adapted from (Hamidah Yusof et al., 2015)

DATA ANALYSIS

As discussed, the study focused on measuring the usability of virtual microscopy in the context of sixth-form education. Based on the collected data, the overall views of the respondents were reasonably positive towards the use of the HistoGuide application, the flexibility provided in the mobile applications, and the user-friendly interfaces. Apart from the excessive launching of new mobile applications every day, the results have shown great satisfaction in using the application by Gen Z students.

The characteristics of the respondents in this study were classified based on gender only because it is just a study of 33 respondents from the same centre. Based on the demographic data, namely the gender of the respondents, it can be seen that the male respondents are 13 people, with a percentage of 39.0%. In comparison, the female respondents of 20 people, with 61.0% of the total number of respondents. Females dominate the gender of HistoGuide application users.

There are four constructs tested in this study, namely the constructs "Usefulness", "Ease of Use", "Ease of Learning", and "Satisfaction". This parameter has 30 statements represented by each construct. The process of calculating parameter attributes uses a 5-point Likert scale, namely Strongly Disagree (value 1), Disagree (value 2), Neutral (value 3), Agree (value 4), and Strongly Agree (value 5). The validity of the instruments was determined using Cohen's kappa coefficients. The Cohen kappa is 0.90, and according to Cohen (1960), Cohen's kappa coefficient, κ > 0.81, showed a very good agreement between the raters. Since Cohen's kappa coefficient is greater than 0.81, the instrument developed is valid to be used as a questionnaire to test the usability of the HistoGuide application.

Then, the pilot study's reliability test was carried out by calculating Cronbach's alpha coefficient value. The Cronbach's alpha coefficient results are obtained from analyzing calculations using SPSS software. The reliability test is carried out by entering all the answers from all valid statements, namely 30 items, and producing a Cronbach's alpha value of 0.920. Based on the reliability level of Cronbach's alpha described in Table 4.2, the value of 0.920 is in the range of $0.90 < r \leq 1.00$, so the test results can be concluded that the reliability of the questionnaire is excellent. The construct's Cronbach's alpha for usefulness, ease of use, ease of learning, and satisfaction are 0.712, 0.779, 0.733 and 0.752, respectively. Hence, the test results for each construct can be concluded that the reliability of each construct is good. So, in summary, the constructs of the statements and answers from the questionnaire are declared reliable so that further data processing can be carried out.

In the study, the summary of the collected data is shown in Figure 4.1, highlighting that most of the respondents agree with the usability of the user interface through positive approval of the questionnaire's statements. The figure represents the association between two attributes; the horizontal axis shows each construct's acceptance level, while the vertical axis emphasizes the number of respondents. The figure points out that, in most cases, the level of agreement towards each construct is very high. On the whole, the number of respondents who agreed on "Usefulness", "Ease of Learning", "Ease of Use", and "Satisfaction" were 264, 357, 130, and 231, respectively. The evidence shows that agreement level is far better than disagreement (none actually), proving that the users are strongly dependent on and satisfied with the HistoGuide application.

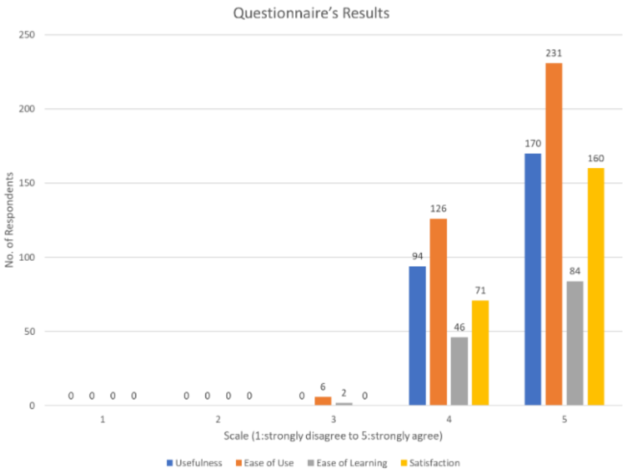

Figure 4: Questionnaire's results

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Furthermore, the reflection of the collected data is shown in Table 4.1. The strongly agreed respondents have the highest percentage compared to the other groups. If consideration for all agreement levels is considered, the agreement rate will be clear for understanding. As evidence, the respondent's responses measure 100.0% for usefulness, 98.0% for ease of learning, 98.0% for ease of use, and 100.0% for satisfaction. The response details for each construct and respective statements are further illustrated in Figures 5 to 6.

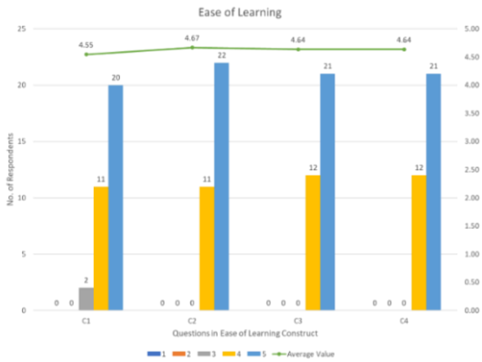

Figure 5: Ease of Learning Construct

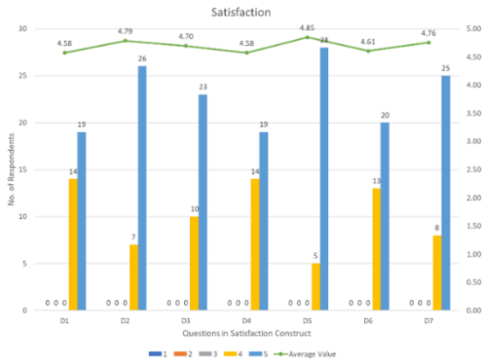

Figure 6: Satisfaction Construct

Table 3 shows the measurement results of usability of the HistoGuide application with the mean score of 4.64 and 92.8%, under the classification of "High". It means that the HistoGuide application already has a very good usability value.

Table 3: Usability Index of HistoGuide

	Mean Score	Standard Deviation	Percentage * (%)	Mean score ** Level
Usefulness	4.64	0.2635	92.8	High
Ease of Use	4.62	0.2713	92.4	High
Ease of Learning	4.62	0.3756	92.4	High
Satisfaction	4.69	0.2815	93.8	High
Usability	4.64	0.2581	92.8	High

* Note: Percentage is counted using the formula (mean score*100/5).
** Note: Mean score level is deciphered from Table 3.0.

DISCUSSION

In addition to the knowledge attainment measure and solving the microscopic drawing and labelling problems, the study revealed that students had a positive perception of the usability of virtual microscopy as a learning tool, evidenced by a significantly higher satisfaction score of 93.8%. Although several past studies have recorded students' opinions, insufficient data is drawn from directly measuring students' level of satisfaction with virtual microscopy or optical microscopy. A study by

Hande et al. measured student satisfaction using optical, virtual, and optical and virtual microscopes (Hande et al., 2017). The study showed high satisfaction (87.6%) with virtual microscope usage (Hande et al., 2017).

There is very limited research on usability testing in sixth-form laboratory practicals using virtual microscopy as a learning tool. However, many research studies support virtual microscopy as an essential educational concept in the classroom and learning in undergraduate studies. This study provides positive outcomes for students utilizing virtual microscopy to identify organisms and cells, labelling, applying magnification and scale, and observing details. The implementation of virtual microscopy in sixth-form biology education can successfully improve the student's confidence through their mastery of the learning experience, which eventually can measure their knowledge of the laboratory science subjects in preparation for pursuing their tertiary education.

Several other studies explored students' opinions toward the use of virtual microscopy. Overall, these studies reported several advantages of using a virtual microscope as a learning tool, namely easy navigation with optimum contrast, clear images, presence of interactive features that allow collaborative learning and easy access to virtual microscopy for self-regulated study (Donnelly et al., 2012; Helle et al., 2011; Krippendorf & Lough, 2005; Nauhria & Hangfu, 2019; Ordi et al., 2015; Saco et al., 2016). However, it should be noted that some students and educators had also indicated a strong preference for the continued use of traditional microscopy, supplemented with virtual microscopy, as both tools in adjunct optimized students' learning (Neel et al., 2007; Xu, 2013). Raja (2010) presented similar findings, where students accepted optical microscopy as a supplementary learning tool (Harris et al., 2001; Heidger et al., 2002; Pratt, 2009). Currently, sixth-form microscopic practicals are designed to evaluate each specimen for identification and analysis through the physical mastery of optical microscopy.

Despite the students' preferences for virtual microscopy instruction, the current designs of laboratory sciences are designed through optical microscopy learning and curriculum. It reflects the uncertainty of virtual microscopy providing equivalent instruction and learning compared to optical microscopy instructions (Brueggeman et al., 2012). However, the fact that students are highly computer competent, and perceive that they can learn as well or better from virtual microscopy when compared to optical microscopy, reveals a step in the right direction for microscopy learning and education (Coleman, 2013; Cunningham et al., 2008; Mione et al., 2013). Although optical microscopy is considered the preferred method, virtual microscopy has evolved to various levels of success in education (Nelson et al., 2012). Science educators can supplement and enhance their microscopy teaching methodologies by utilizing virtual microscopy, allowing for annotations of significant regions of interest, from cellular to subcellular levels, completed at a distance and through student-instructor collaborations (Dickerson & Kubasko, 2007; Jonas-Dwyer et al., 2011; Kumar et al., 2004; Sivamalai et al., 2011). Previous studies suggest that a crucial factor of virtual microscopy is the facilitation of collaboration (Dickerson & Kubasko, 2007; Kumar et al., 2004; Triola & Holloway, 2011).

The assumptions presented in this study were: (a) virtual microscopy will have an influence on the way that students perceive laboratory activities; (b) the sample selected is representative and adequate; (c) the researcher maintains neutrality on teaching with digital or virtual technology. The study's limitations were as follows: (a) students will find it inconvenient to use virtual or digital microscopy when interpretation is to be obtained from cloud base secure systems, and (b) the internet availability in schools.

This study adds to the body of research on sharing the usability testing of sixth-form biology students during the implementation of virtual microscopy as an educational learning tool in microscopic techniques. In the construct of "Usefulness", whereby the lowest average value is obtained in the statement of A4, "HistoGuide gives me more control over the activities carried out during practicals". Hence, further improvement to the application is suggested by incorporating an overview map at the end of each module, whereby users can navigate from one section to another. This enables users to control their activities. In the construct of "Ease of Use", whereby the lowest average value is obtained in the statement of B10, "I can recover from mistakes in drawing and labelling quickly". Hence, further improvement is suggested in the image upload section, whereby users are reminded to share and comment on each other's images and drawings. Thus, it reduces the chances of mistakes, and users can recover from them quickly, if any.

Further research is recommended in the following areas to help improve sixth-form laboratory practicals. This study can be replicated by having future researchers expand the number of students included. In addition, researchers might study the learning experiences of students enrolled in matriculation colleges, as the same syllabus is involved. Further research should require a larger population. Furthermore, a study using both quantitative and qualitative methodologies to compare usability testing will help evaluate the positive effects of virtual microscopy in the curriculum. Lastly, researching all sixth-form centres and matriculation colleges with the same syllabus involved with the instructional delivery of microscopic techniques via virtual microscopy can validate the preference for virtual microscopy in microscopic practicals.

This innovation in teaching and learning will indeed definitely have a high impact on the students and teachers in sixth-form centres and matriculation colleges. It will increase the productivity of students and teachers when executing microscopic practical works.

CONCLUSION

HistoGuide application as virtual microscopy and slide changed how people worked on microscopic practicals. The advancement in this field has allowed users, especially students, to have a flexible environment with most online services available on their smartphones for self-regulated learning and collaborative learning. The latest development in virtual microscopy also provides new research ideas based on the usability perspective. The USE survey for user interface satisfaction helps developers get a more detailed understanding of the potential problems of the HistoGuide application. This pilot study measures user satisfaction on four constructs: usefulness, ease of use, ease of learning and satisfaction. The results indicated that the HistoGuide application is relevant and interesting to the students. The application enabled the students to draw and label, apply magnification and scale, and observe detail better, as in the construct "Usefulness", particularly on the statements A3, A5 and A7. The analysis yielded an average value of the "Usefulness" construct of 92.8%. Then the construct "Ease of Learning" with 92.4%, the smallest is "Ease of Use" with 92.4%, and the highest is "Satisfaction" with 93.8%. These results indicate that the HistoGuide application is good. Overall, the results of measuring the usability of the HistoGuide application were noted with the classification "High" to use, with a usability value of 92.8%. The results of usability measurement are expected to help develop and improve the HistoGuide application in the future to complement the conventional microscopic practical works, besides addressing the students' main problems in drawing and labelling, applying magnification and scale, and observing details.

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