Research Article

HistoGuide's (Virtual Microscopy and Slides) Development and Usability

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Abstract: *HistoGuide application is a smartphone application system used by sixth-form students as 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 in the second round of the study. 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 practical works. The improvised HistoGuide application showed high content validity of individual items (I-CVI range: 0.75 to 1.00) and excellent content validity of the overall validation (S-CVI/UA = 0.83; S-CVI/Ave = 0.96). In addition, the overall Cohen kappa is 0.96. Together with the findings from the need analysis, there is a need for future studies using the HistoGuide application.*

Keywords: HistoGuide Application; Virtual Microscopy and Slides; Usability; USE Questionnaire.

1. 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, during the lockdown to replace laboratory work. However, during post-pandemic, these practices have continued, and thus, the students' manipulative skills (dexterity) acquirement has been a concern when it comes to laboratory work.

Preliminary findings from two biology classes in Pusat Tingkatan Enam (PTEVI) showed that 68.8% of students scored below five marks 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 considered weak in drawing, labelling and applying magnification and scales. Drawing and labelling aspects must be fulfilled together to acquire the allocated marks. Cheung and Winterbottom (2021) supported the findings, which explored students' visualisation 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 tended to give fewer labels (Cheung & Winterbottom, 2021). In addition, students have a moderately low level of sketching skills (Fatimah Mohamed et al., 2011).

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 1.1. 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).

Hence, a comprehensive guideline is necessary to guide students in executing biology microscopic practicals in sixth-form education (STPM/pre-university/matriculation). 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 students' confidence level and motivation in executing the microscopic practicals. Thus, using Celebrate application is proposed in the first round of study involving two classes in PTEVI. Results from the first study round showed that the usability findings are inconclusive since the application is non-catering to the needs of the STPM/pre-university/matriculation level. Hence, the findings and outcomes in the first study round proved that much work is needed. Thus, the second round of action research is still needed and proposed to be carried out, as described by Chua (2020); Cohen et al. (2018) in their published books.

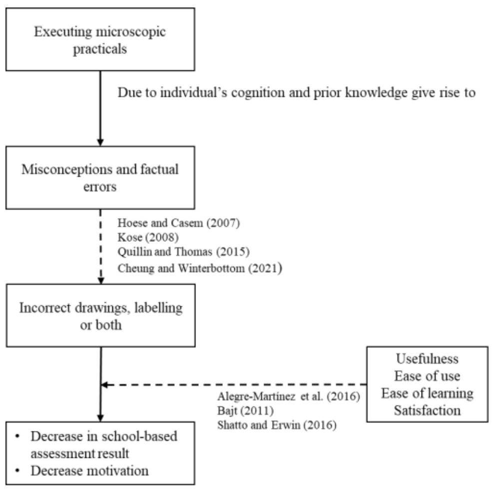


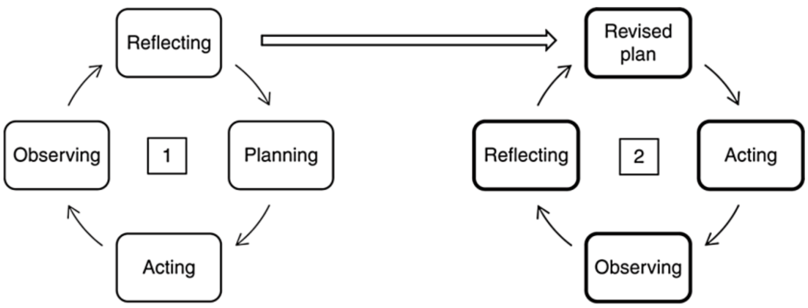
Figure 1.1. *Symptoms/Issues Arise during the Execution of Microscopic Practicals*

Action research is any systematic investigation undertaken by teachers, administrators, counsellors, or anyone with a vested interest in the teaching and learning process or environment to acquire information about how their specific schools work, how they teach and how their students learn (Mills, 2017). As mentioned by Chua (2020), action research is a) conducted to solve social problems, b) related to social practices, c) conducted to improve the current situation, d) a reflective process, e) a repetitive process, f) conducted systematically, g) determined by the practitioners and h) problems in action research are related to social behaviour. So, the action research method is appropriate to be carried out in schools. The chronological development of action research is listed in Table 1.1.

Table 1.1. *Chronological Development of Action Research*

No	Researcher	Year	View/ Description
1	Kurt Lewin	1946	Researched social issues Often described as the major contributor in action research as a methodology
2	Stephen Corey	1954	Applied action research into educational issues
3	Lawrence Stenhouse	1975	Used action research to study the theory and practice of teaching and the curriculum
4	Elliot and Adelman	1976	Used action research in their Teaching Project when examining classroom practice
5	Lawrence Stenhouse	1983	Action research was about emancipation and intellectual, moral and spiritual autonomy
6	Cohen and Manion	1994	Action research is on the spot procedure designed to deal with a concrete problem located in an immediate situation
7	Bassey	1998	Action research is an enquiry that is carried out to understand, evaluate and change to improve educational practice
8	Bell	1999	Action research is practical, and the nature of the problem-solving approach results in a greater understanding
9	Zeichner	2001	It gives an overview of how action research developed as a research tradition
10	Hopkins	2002	

The researchers suggest many models in action research (L. Cohen et al., 2018). Action research is a repetitive process. Hence, there can be many cycles to the action research until the goal is achieved. One chosen action research model for this study is shown in Figure 1.2. Action research is a repetitive process, as in Figure 1.3.



Source: Adapted from Stringer (2007), Kemmis and McTaggart (1992), Zuber-Skerritt (2001)

Figure 1.2. *Summary of Action Research Model*

To date, there is still a lack of comprehensive guidelines for after-secondary education in Malaysia, especially for STPM/pre-university/matriculation. Hence, a new application that caters to the needs is developed and proposed for the second round of action research involving all classes in PTEVI. It is because students from all classes in PTEVI still encounter the same issues in drawing, labelling and applying magnification and scales. The HistoGuide 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.

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 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 standardised 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 analysed to gauge the usability of the HistoGuide application.

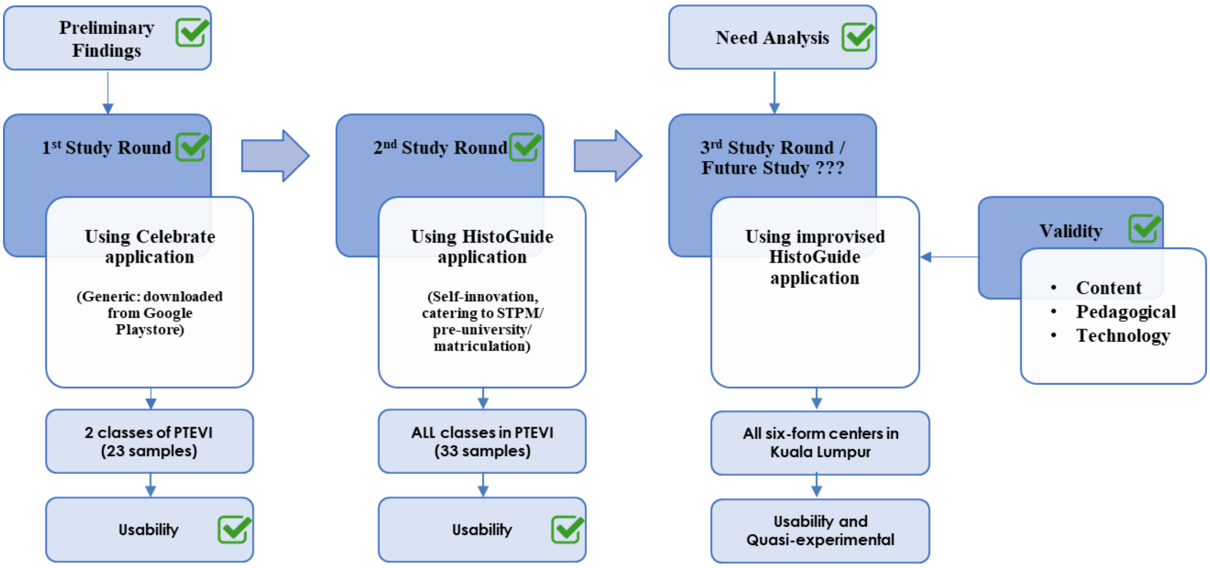


Figure 1.3. *Progression of Action Research for HistoGuide Application*

2. METHOD & MATERIAL

The objectives of this study include the following:

1. To determine the usability of the HistoGuide application in sixth-form microscopic practicals in helping students to draw and label precisely, besides applying magnification and scale.
2. To develop the HistoGuide application in sixth-form microscopic practicals with a high validity index.
3. To determine whether there is a need for future study through the need analysis.

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. In the second round of the action research, 33 samples were acquired**.** Then, experts validated the HistoGuide application in content, pedagogical, and technology aspects. The sample of the HistoGuide application is illustrated in Figure 3.1. At the same time, the procedure of the studies is outlined in Figure 3.2.

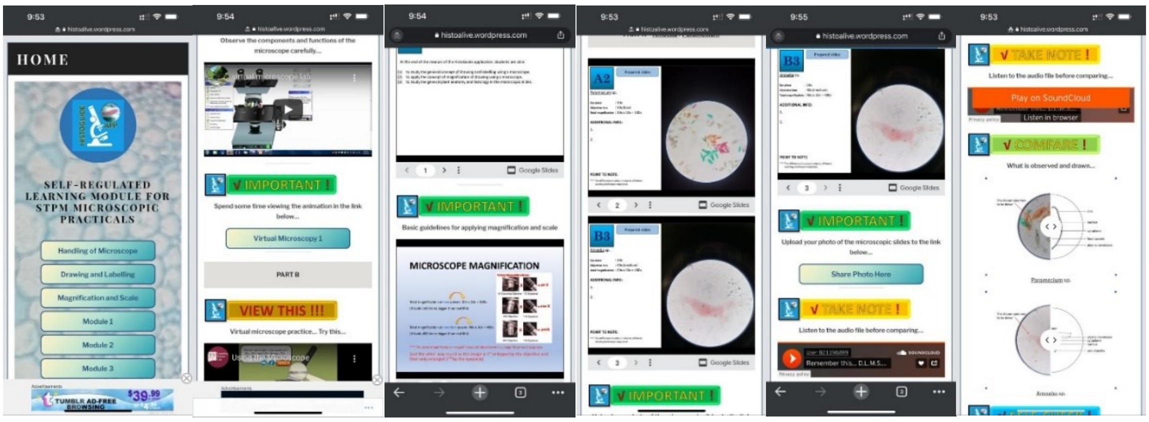


Figure 3.1. *Samples of the HistoGuide Application (Before Validation)*

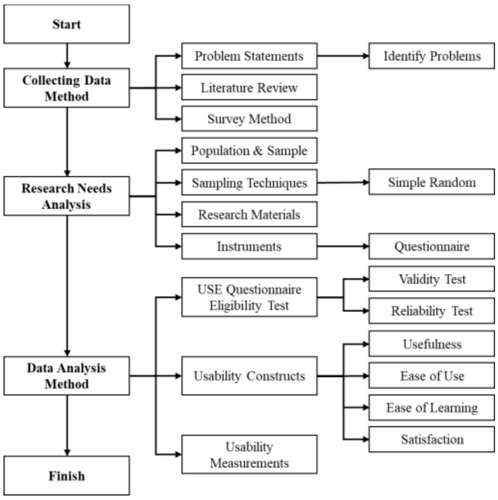


Figure 3.2. *Procedure of Study*

In the survey design, the questionnaire technique was employed. Lund (2001) proposed utilising 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 3.1.

Table 3.1. *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:

$$\text{Interval scale of mean score} = \frac{highest\ value - lowest\ value}{number\ of\ class\ interval} = \frac{5-1}{3} = 1.33$$

Based on the calculation above, the levels in the mean score are shown in Table 3.2.

Table 3.2. *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)

As a newly developed mobile application, the HistoGuide underwent strong content validation. A systematic analysis of the test content to evaluate whether it covers a representative sample of the domain of behaviours to be measured is known as content validity (Jackson, 2006). Content validity refers to the degree of agreement between the content actually measured by a scale and the content to be measured.

The most widely used index in the quantitative evaluation of the content validity of a scale is the content validity index (Polit et al., 2007). For content validity index (CVI), I-CVI, S-CVI/UA and S-CVI/Ave are employed. The method for measuring content validity is calculating the Item-level CVI (I-CVI). However, an alternative, unacknowledged method to measure content validity is Scale-level CVI (S-CVI), which can be calculated using S-CVI/UA or S-CVI/Ave. These two approaches can lead to different values, making it difficult to draw the proper conclusion about content validity (Rodrigues et al., 2017). I-CVI measures the content validity of individual items, while the S-CVI calculates the content validity of the overall scale. Most papers report the I-CVI or the S-CVI but not both. This paper considered both the I-CVI and the S-CVI since the S-CVI is an average score that outliers can skew. Items with an I-CVI of 0.78 or higher for three or more experts could be considered evidence of good content validity (Polit et al., 2007).

3. FINDINGS

3.1 Findings on the Research Objectives 1:

The characteristics of the respondents in this study were classified based on gender only because it is just a study of 33 respondents from PTEVI. 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 are 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, a reliability test was carried out by calculating Cronbach's alpha coefficient value in the first round of action research. The Cronbach's alpha coefficient results are obtained from analysing 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 ≤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 emphasises 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.

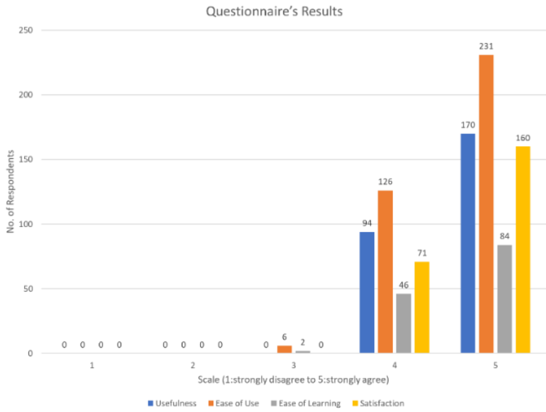


Figure 4.1 *Questionnaire's Results*

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. The agreement rate will be clear for understanding if all agreement levels are considered. 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 4.2 to 4.5.

Table 4.1. *Responses to the USE Questionnaire*

	Usefulness	Ease of Use	Ease of Learning	Satisfaction
Strongly Disagree	0	0	0	0
%	0	0	0	0
Disagree	0	0	0	0
%	0	0	0	0
Neutral	0	6	2	0
%	0	2.0	2.0	0
Agree	94	126	46	71
%	36.0	35.0	35.0	31.0
Strongly Agree	170	231	84	160
%	64.0	64.0	64.0	69.0
Total	264	363	132	231
%	100.0	100.0	100.0	100.0

The below section provides a graphical representation highlighting the responses collected for each construct used in the questionnaire. Figure 4.2 demonstrates the summary of responses collected for the construct "Usefulness". Eight statements were asked to assess the performance and satisfaction of the respondents with the usefulness of the HistoGuide application. The average value on the "Usefulness" construct reaches 4.76, or 95.2%, which is high because it is close to the maximum value. These results imply that the HistoGuide application has a high usability value in the usefulness construct. The eight statements in Figure 4.2 have a scale of 4.00 and above; the highest average value is in statements A3 and A5, 4.76. Statements A3, A5, and A7 (average value of 4.76, 4.76 and 4.61, respectively) are rather important in the usability studies as the statements are related to the problem statements, whereby using the HistoGuide application will help the users to be able to draw and label better.

Figure 4.3 specifies the statements associated with "Ease of Use". This construct was investigated with the help of eleven distinct statements. The responses to the statements asked for this dimension have positive properties only. However, the lowest agreed response was received for statement B10. This question belongs to "I can recover from mistakes quickly". Surely, less agreement is associated only with the sample users. Still, it confirms that respondents do not think recovering from mistakes is easy using the HistoGuide application. In contrast, the highest agreed component for this construct was statement B9, 4.79, which is about whether the occasional users would like the HistoGuide application. The respondents suggest that they are very positive about it. The average value on the "Ease of Use" construct reaches 4.79 or 95.8%, which is very high because it is almost close to the maximum value. These results mean that the HistoGuide application has a high usability value on the "Ease of Use" construct.

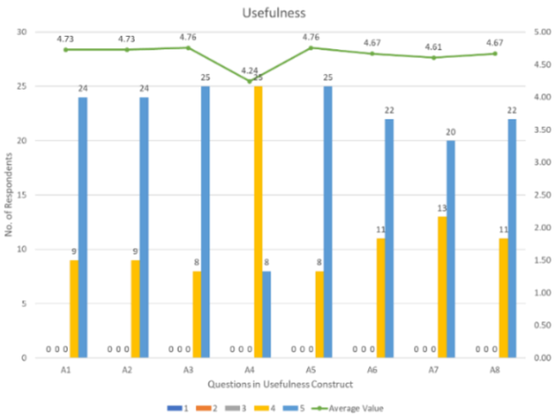


Figure 4.2. *Usefulness Construct*

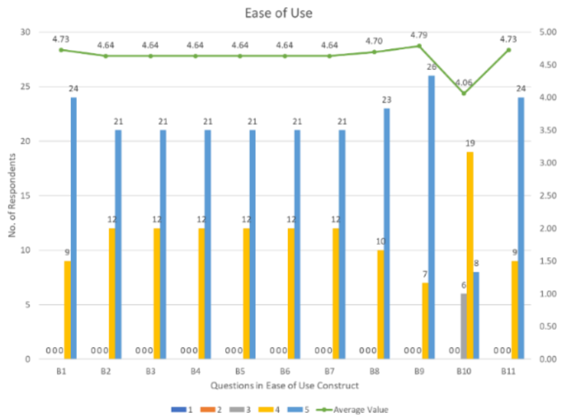


Figure 4.3. *Ease of Use Construct*

The next figure in this section is Figure 4.4, illustrating the responses collected for the construct "Ease of Learning". The figure shows that this construct was assessed through four statements only. Overall, the percentage of agreeing is high for all statements asked for this construct. It demonstrates that respondents favour the HistoGuide application, which is easy to learn and does not require more effort to work on it. The average value on the "Ease of Learning" construct reaches 4.67 or 93.4%, which is high because it is almost close to the maximum value. These results mean that the HistoGuide application has a high usability value on the "Ease of Learning construct". Of the four statements in Figure 4.4, the four attributes of this construct are consistent with being on a scale from 4.00 upwards, and the highest average value is in statement C2, namely 4.67.

Finally, the last figure in this section shows the summary of the construct known as "Satisfaction", as shown in Figure 4.5. Seven statements were asked to measure this variable related to pleasant in use and working environment. The respondents agreed positively with the statements and were pleased using the HistoGuide application. Many respondents voted for statement D5, which relates to the satisfaction level with the HistoGuide application as a wonderful application. The average value on the "Satisfaction" construct reaches 4.85 or 97.0%, which can be quite high because it leads to a positive assessment. These results mean that the HistoGuide application has a fairly high usability value on the "Satisfaction" construct. Of the seven statements in Figure 4.5, the highest average value is found in statement D5, with an average value of 4.85.

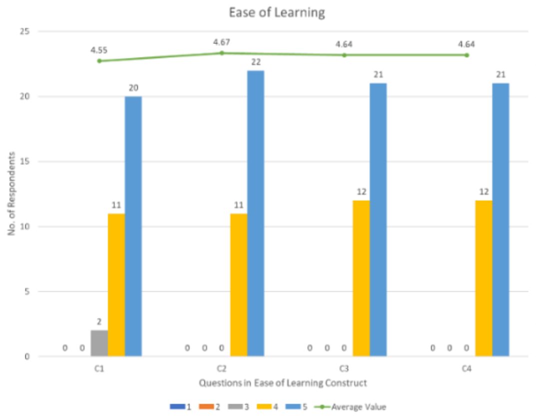


Figure 4.4. *Ease of Learning Construct*

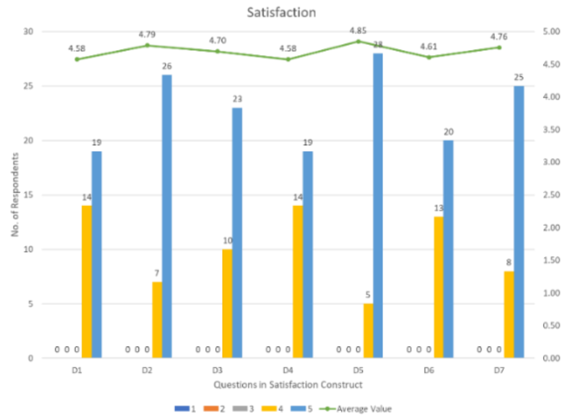


Figure 4.5. *Satisfaction Construct*

Table 4.2 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 4.2. *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).
** Mean score level is deciphered from Table 3.2.

3.2 Findings on the Research Objectives 2:

From Table 4.3, the I-CVIs of all the 30 items in the HistoGuide application validation ranged from 0.75 to 1.00, with only five items having an I-CVI of less than 0.78. Values range from 0 to 1, where I-CVI > 0.79, the item is relevant; between 0.70 and 0.79, the item needs revisions, and if the value is below 0.70, the item is eliminated (Zamanzadeh et al., 2015). Hence, none of the 30 items is eliminated. Only five undergo minor revisions. However, CVI alone is insufficient. Therefore, kappa statistic was employed together. Kappa statistic is a consensus index of inter-rater agreement that adjusts for chance agreement and is an important supplement to CVI because kappa provides information about the degree of agreement beyond chance (Polit et al., 2007). Table 4.3 shows that the five items are still good, whereas the rest of the 25 items are excellent.

Table 4.3. *Ratings on a 30-Item Scale by 11 Experts: Item Rated 3 or 4 on a 4-Point Relevance Scale*

Experts	01	02	03	04	05	06	07	08	09	10	11	Experts in Agreement	Item CVI	p_c	k^*	Evaluation
Items																
Content																
C1	/	/	/									3	1.00	0.125	1.00	Excellent
C2	/	/	/									3	1.00	0.125	1.00	Excellent
C3	/	/	/									3	1.00	0.125	1.00	Excellent
C4	/	/	/									3	1.00	0.125	1.00	Excellent
C5	/	/	/									3	1.00	0.125	1.00	Excellent
C6	/	/	/									3	1.00	0.125	1.00	Excellent
C7	/	/	/									3	1.00	0.125	1.00	Excellent
C8	/	/	/									3	1.00	0.125	1.00	Excellent
C9	/	/	/									3	1.00	0.125	1.00	Excellent
C10	/	/	/									3	1.00	0.125	1.00	Excellent
Proportion Relevant	1.00	1.00	1.00									Average I-CVI	**1.00**			
												S-CVI/UA	**1.00**			
												S-CVI/Ave	**1.00**			
Pedagogy																
P1				/	/	/	/					4	1.00	0.063	1.00	Excellent

P2				X	/	/	/					3	0.75	0.250	0.67	Good
P3				/	/	/	/					4	1.00	0.063	1.00	Excellent
P4				X	/	/	/					3	0.75	0.250	0.67	Good
P5				/	/	/	/					4	1.00	0.063	1.00	Excellent
P6				X	/	/	/					3	0.75	0.250	0.67	Good
P7				/	/	/	/					4	1.00	0.063	1.00	Excellent
P8				/	/	/	/					4	1.00	0.063	1.00	Excellent
P9				/	/	/	/					4	1.00	0.063	1.00	Excellent
P10				X	/	/	/					3	0.75	0.250	0.67	Good
Proportion Relevant				0.60	1.00	1.00	1.00					Average I-CVI	**0.90**			
												S-CVI/UA	**0.60**			
												S-CVI/Ave	**0.90**			
Technology																
T1								/	/	/	/	4	1.00	0.063	1.00	Excellent
T2								/	/	X	/	3	0.75	0.250	0.67	Good
T3								/	/	/	/	4	1.00	0.063	1.00	Excellent
T4								/	/	/	/	4	1.00	0.063	1.00	Excellent
T5								/	/	/	/	4	1.00	0.063	1.00	Excellent
T6								/	/	/	/	4	1.00	0.063	1.00	Excellent
T7								/	/	/	/	4	1.00	0.063	1.00	Excellent
T8								/	/	/	/	4	1.00	0.063	1.00	Excellent
T9								/	/	/	/	4	1.00	0.063	1.00	Excellent
T10								/	/	/	/	4	1.00	0.063	1.00	Excellent
Proportion Relevant								1.00	1.00	0.90	1.00	Average I-CVI	**0.98**			
												S-CVI/UA	**0.90**			
												S-CVI/Ave	**0.98**			

Note:
Expert 01: Cell Histology and Morphology
Expert 02: STPM Biology Content Expert (>30 years), Ex-Science Education Specialist at SEAMEO RECSAM
Expert 03: Neuroscience, Histology
Expert 04: Chemistry Education, Module Development, Instructional Technology, Quantitative Analysis
Expert 05: Education (Science), Research Method
Expert 06: Mathematics Education, Research Method
Expert 07: Science Education, Teacher Education, Qualitative Research Method
Expert 08: Education Technology
Expert 09: IT/Multimedia, Game Design and Development
Expert 10: Multimedia in Education, Multimedia Applications, E-learning
Expert 11: Multimedia in Biology
p_c (probability of a chance occurrence) was calculated using the formula for a binomial random variable, with one specific outcome: $p_c = [N!/A!(N - A)!]*.5^N$ where N = number of experts and A = Number agreeing on good relevance.
k^* = kappa designating agreement on relevance: $k^* = (\text{I-CVI} - p_c)/(1 - p_c)$.
Evaluation criteria for kappa, using guidelines described in Cicchetti and Sparrow (1981) and Fleiss (1981): Fair = k* of 0.40 to 0.59; Good = k^* of 0.60 to 0.74; and Excellent = k^* > 0.74.

Next, as in Table 4.4, the S-CVI/UA for content, pedagogy, technology and overall aspect of the HistoGuide application are 1.00, 0.60, 0.90 and 0.83, respectively. The S-CVI/Ave for content, pedagogy, technology and overall aspect of the HistoGuide application are 1.00, 0.90, 0.98 and 0.96, respectively. A S-CVI/UA ≥ 0.8 and a S-CVI/Ave ≥ 0.9 have excellent content validity (Shi et al., 2012). However, the overall content validity index of the instrument using the universal agreement approach was low for pedagogy (0.60). Thus, it can be advocated the high number of content experts that makes consensus difficult (Zamanzadeh et al., 2015) and compensates by the high value of the S-CVI with the average approach, which was equal to 0.90.

Table 4.4. *Summary of Average I-CVI, S-CVI/UA and S-CVI/Ave*

	Content [a]	Pedagogy [b]	Technology [c]	Overall [d]
Average I-CVI	1.00	0.90	0.98	0.96
S-CVI/UA	1.00	0.60	0.90	0.83
S-CVI/Ave	1.00	0.90	0.98	0.96

Note:
a evaluated by Experts 01, 02 and 03
b evaluated by Experts 04, 05, 06 and 07
c evaluated by Experts 08, 09, 10 and 11
d is the average of the three constructs (content, pedagogy and technology)

In addition, the validity of the HistoGuide application was determined using Cohen's kappa coefficients. The kappa coefficient on a 4-point agreement scale for content, pedagogy, technology and overall aspect of the HistoGuide application are 0.90, 0.70, 0.90 and 0.83, respectively. Meanwhile, the kappa coefficient on a 2-point agreement scale for content, pedagogy, technology and overall aspect of the HistoGuide application are 1.00, 1.00, 0.90 and 0.96, respectively. Both showed a very good agreement between the raters, as in Table 4.5.

Table 4.5. *Summary of Cohen Kappa Validity Index*

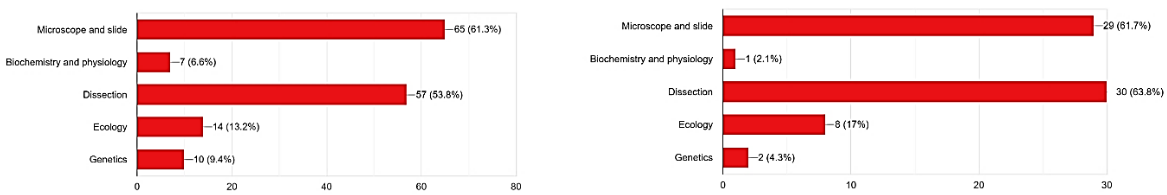
	Content [a]	Pedagogy [b]	Technology [c]	Overall [d]
Cohen Kappa validity index on a 4-Point Agreement Scale	0.90	0.70	0.90	0.83
Description for Cohen Kappa on a 4-Point Agreement Scale	Very Good	Good	Very Good	Very Good
Cohen Kappa validity index on a 2-Point Agreement Scale	1.00	1.00	0.90	0.96
Description for Cohen Kappa on a 2-Point Agreement Scale	Very Good	Very Good	Very Good	Very Good

Note:
a evaluated by Experts 01 and 02
b evaluated by Experts 05 and 06
c evaluated by Experts 10 and 11
d is the average of the three constructs (content, pedagogy and technology)

3.3 Findings on the Research Objectives 3:

The need analysis was carried out through a survey by Google Forms to identify the learning problems sixth-form biology students faced. It involved 106 sixth-form students intake 2022/2023 and 47 teachers. *WhatsApp* and *Telegram* applications were used as the medium to send the access link to the Google Form questionnaire. Findings from both need analyses confirmed the need for the HistoGuide application to address students' misconceptions in microscopic practicals regarding drawing and labelling, the ability to state magnification and scale, and observing details. There were five major items in both need analyses; a) perception of the most difficult subtopic in sixth-form biology laboratory practicals, b) learning difficulties in the mentioned subtopic, c) the preferred learning type/s, d) types of learning criteria(s) that attracts and e) learning type/s that could address the learning difficulties. The data is obtained from the Google Form itself.

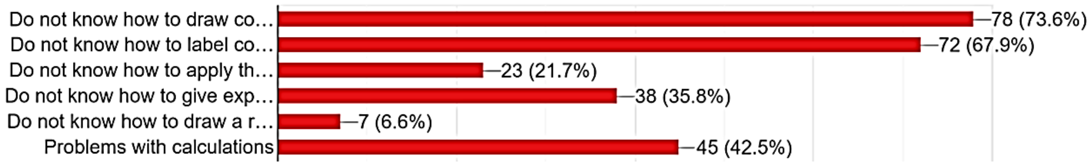
Finding on the students' and teachers' perceptions of the most difficult subtopic in biology laboratory practicals is shown in Figure 4.6. Results revealed that 61.3% of students perceived microscope and slides as the most difficult topic to study, followed by dissection (53.8%) and ecology (13.2%). However, teachers viewed dissection (63.8%), microscope and slides (61.7%), and ecology (17.0%).



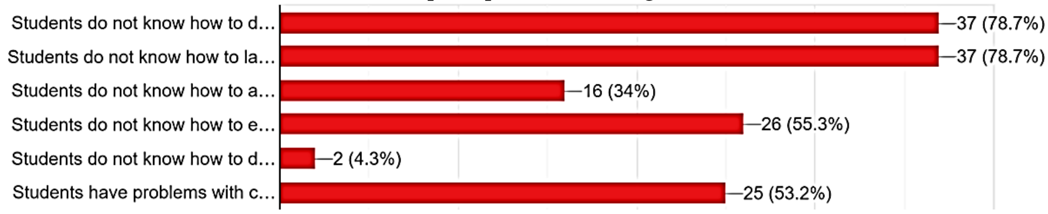
a) students' perception b) teachers' perception

Figure 4.6. *Students' vs Teachers' Perception of the Most Difficult Subtopic*

Finding on the students' and teachers' perceptions of learning difficulties in the subtopic is shown in Figure 4.7. Results revealed students do not know how to draw (73.6%), label (67.9%), give explanations of facts (35.8%), and have problems with calculations (42.5%). The teachers agreed with the student's perception of the aspects of learning difficulties.



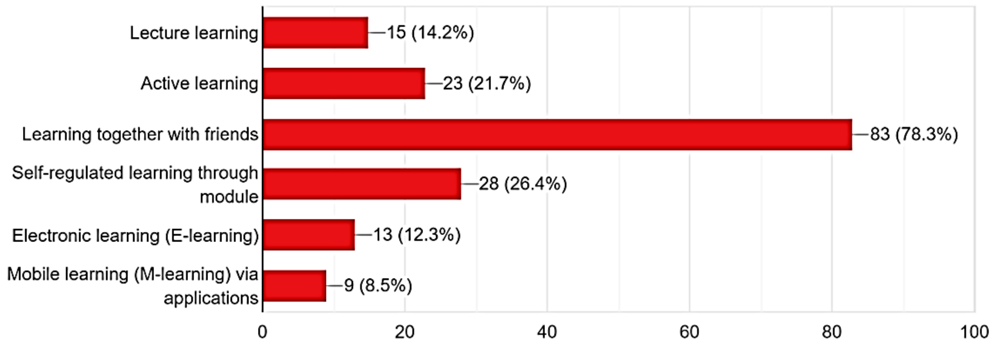
a) students' perception (including others: 17.1%)



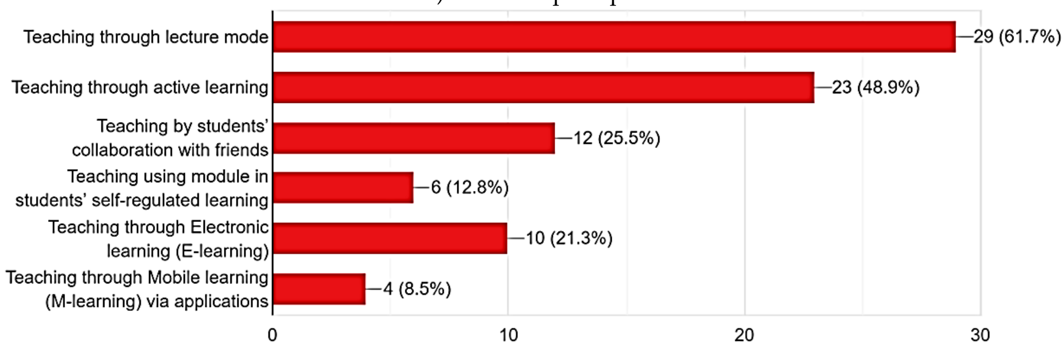
b) teachers' perception (including others: 6.3%)

Figure 4.7. *Students' vs Teachers' Perception of Learning Difficulties in the Mentioned Subtopic*

Finding on the students' and teachers' perceptions of the preferred learning type/s are shown in Figure 4.8. Results revealed students preferred learning with friends (78.3%), self-regulated (26.4%), and active learning (21.7%). On the contrary, the teachers disagree with the notion, as they believe teaching using the lecture method in sixth-form is the best (61.7%), followed by active learning (48.9%), and teaching through students' collaboration with friends (25.5%). There is a mismatch between students' learning and teachers' teaching styles.



a) students' perception



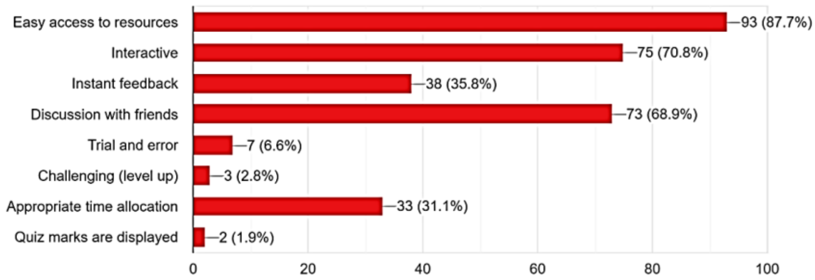
b) teachers' perception

Figure 4.8. *Students' vs Teachers' Perception of Preferred Learning Type/s*

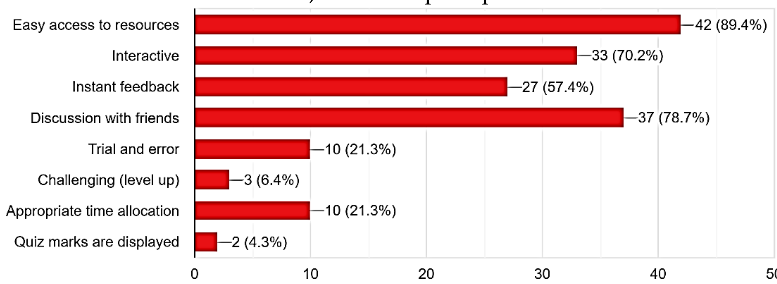
Finding on the students' and teachers' perceptions of types of learning criteria(s) that attract the students is shown in Figure 4.9. Results revealed students preferred easy access to resources (87.7%), interactive (70.8%), discussion with friends 68.9%), and instant feedback (35.8%). The teachers agreed with the student's perception of the learning criteria(s) that attract them.

Findings on the students' and teachers' perceptions of learning type/s that could address the learning difficulties are shown in Figure 4.10. Results revealed students preferred learning with friends

(80.2%), mobile learning via applications (66.0%), and self-regulated learning (65.1%). On the contrary, the teachers disagree with the notion, as they believe teaching using self-regulated learning in the sixth form is the best (95.7%), followed by active learning (78.7%), and teaching through students' collaboration with friends (78.7%). There exist a mismatch between students' and teachers' thoughts on how the learning difficulties could be addressed. Although teachers' perception is considered, students view learning with friends can solve their problems when executing microscopic practicals. However, the STPM syllabus mentioned that the practicals have to be individual-based.

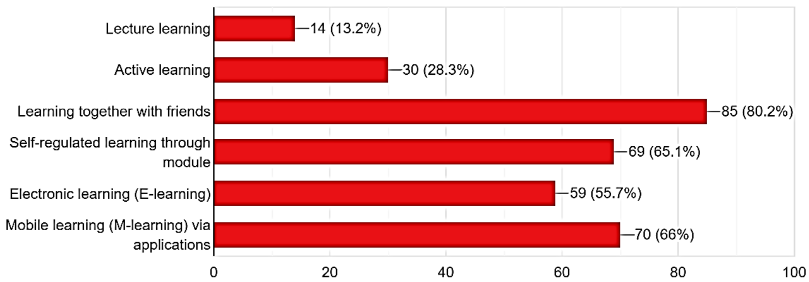


a) students' perception

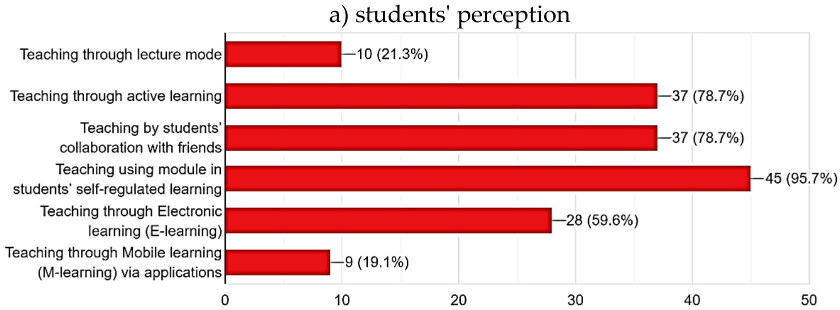


b) teachers' perception

Figure 4.9. *Students' vs Teachers' Perception of Types of Learning Criteria(s) that Attract the Students*



a) students' perception



b) teachers' perception

Figure 4.10. *Students' vs Teachers' Perception of Learning Type/s that Could Address the Learning Difficulties*

4. 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, 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 a high degree of satisfaction (87.6%) toward 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 utilising virtual microscopy to identify organisms and cells, labelling, applying magnification and scale, and observing details. Implementing virtual microscopy in sixth-form biology education can successfully improve the student's confidence through their mastery of the learning experience, which can eventually measure their knowledge of the laboratory science subjects in preparation for 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 optimised 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 utilising 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. It 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.

In summary, the HistoGuide application showed high content validity of individual items (I-CVI range: 0.75 to 1.00) and excellent content validity of the overall validation (S-CVI/UA = 0.83; S-CVI/Ave = 0.96). Besides that, through qualitative methods, the clarity of items was refined for the mentioned five revisioned items (Rodrigues et al., 2017). In addition, the overall Cohen kappa is 0.96, and according to Cohen (1960), Cohen's kappa coefficient, $\kappa > 0.81$, showed a very good agreement between the raters. Since Cohen's kappa coefficient is greater than 0.81, the HistoGuide application is deemed highly valid. Hence, the HistoGuide is developed as a mobile application that can be utilised for self-regulated learning with collaboration among students. In summary, it satisfies the students' and teachers' perceptions of how the issue can be solved. Therefore, the HistoGuide application shall have the following criteria or features; a) easy access to resources, b) interactive, c) collaboration with friends and d) instant feedback.

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. Furthermore, a study using both quantitative and qualitative methodologies to compare usability testing and experimental research will help evaluate the positive effects of virtual microscopy in the curriculum. This innovation in teaching and learning will impact the students and teachers in sixth-form centres, pre-universities and matriculation colleges. It will increase the productivity of students and teachers when executing microscopic practical works.

5. 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 second round action research 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 the development and improvement of the HistoGuide application in the future, besides addressing the students' problems in drawing and labelling, applying magnification and scale, and observing details. The improvised HistoGuide application showed high content validity of individual items (I-CVI range: 0.75 to 1.00) and excellent content validity of the overall validation (S-CVI/UA = 0.83; S-CVI/Ave = 0.96). In addition, the overall Cohen kappa of 0.96 showed a very good agreement between the raters. Together with the findings from the need analysis, there is a need for future studies using the HistoGuide application.

Novelty:

The HistoGuide application is the first Malaysian virtual microscopy and slides, as shown in Figure 5.1, catering to the students' microscopic practicals in STPM, pre-university or even matriculation colleges. The benefits are as follows for the students:

a) Addresses the students' problems in drawing and labelling, applying magnification and scale, and observing details.
b) As self-regulated learning.
c) Increases students' preparedness for practicals.
d) Increases students' motivation for practicals.
e) As alternative reliable source of reference.
f) Using information technologies in collaborative contexts pre-laboratory and during microscopic practicals.

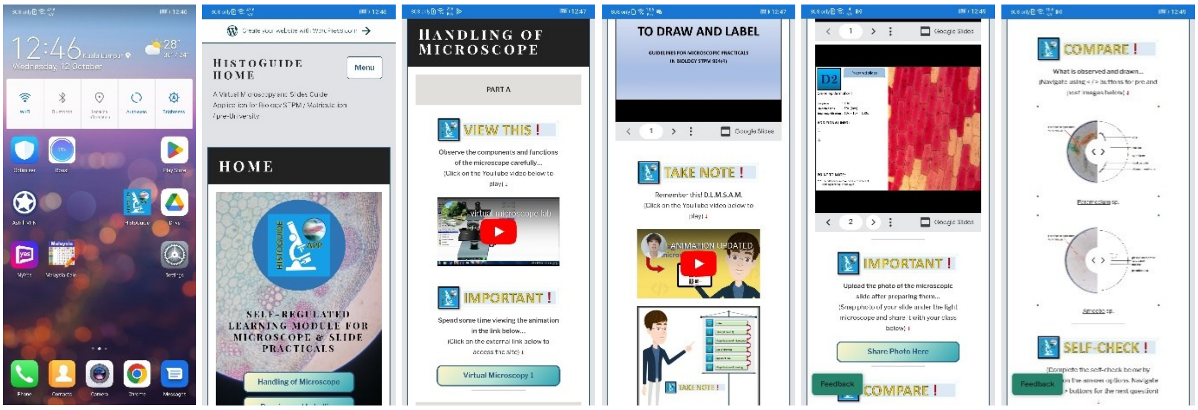


Figure 5.1. *The novelty of the HistoGuide Application (After Validation and Need Analysis)*

Creativity:

The HistoGuide application has many functions catering to the students' microscopic practicals, whether in STPM, pre-university or even matriculation colleges, as shown in Figure 5.2. The main features are; a) easy access to reliable resources, b) interactive, c) collaboration with friends, and d) instant feedback.

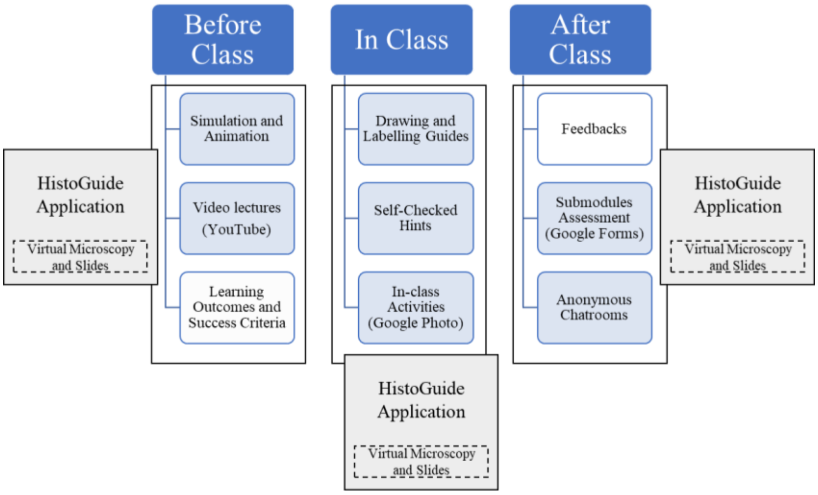


Figure 5.2. *The Creativity in HistoGuide Application Explained*

Applicability:

The HistoGuide application caters to the students' microscopic practicals in STPM, pre-university or even matriculation colleges using android or iOS operating systems on their mobile phones and tablets.

Lastly, the benefits of the HistoGuide application are also applicable to teachers. They are:

a) Teachers can concentrate and gives ample guidance without much explanation, as microscopic practicals involves high dexterity and technical skills, which, the students require ample guidance from the teacher.
b) The teaching resources is not limited to lecture notes, modules, reference books, and tutorial questions but interactive teaching materials like the HistoGuide application.
c) The teaching of usually individual-based microscopic practicals can be explored collaboratively.

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