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The need for an educational comic on science laboratory safety

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ABSTRACT

In the study of design and development, one of the vital stages that need to be carried out is the needs analysis. In this study, a needs analysis is carried out to ensure that the educational comic produced is suitable for the users' needs. This quantitative survey study was carried out to see the need for the development of the science laboratory educational comic on improving science laboratory safety awareness among secondary school students as well as to see students' awareness and knowledge towards science laboratory safety. A set of needs analysis questionnaires was given to 131 secondary school students throughout Malaysia. The data obtained were analyzed descriptively, such as frequencies and percentages using Statistical Package for the Social Sciences (SPSS) version 23.0. The results of the analysis show that most respondents agree that this module is suitable for science laboratory safety awareness. A moderate level of average mean score of 3.53 also indicates that the level of awareness of regulations in the laboratory among average students is still low and needs to be improved. A high average mean score of 3.90 of respondents agreed that the development of a science laboratory safety educational comic should be developed to improve science laboratory safety awareness among secondary school students. Most respondents agreed that emphasis should be placed on content and technical approaches in educational comics to develop a science laboratory safety educational comic that suits the needs of students, with a high average mean score of 3.73. The results of this study provide a brief overview of the need for a science laboratory educational comic on improving science laboratory safety awareness among secondary school students.

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1. INTRODUCTION

In Malaysia, students typically engage in practical work, experiments, and laboratory activities in student-oriented laboratories as a crucial part of science education. This emphasis on practical work aims to foster scientific inquiry and the acquisition of knowledge with scientific skills. By employing an inquiry-discovery approach, both teachers and students in science laboratories can explore scientific concepts through hands-on activities. Adane and Abeje [1] recognize that the use of science laboratories to test theories and nurture scientific ability is universally acknowledged, while Hofstein and Mamlok-Naaman [2] state that science laboratories help students build experience through interactions with various materials and equipment.

However, it is important to recognize the risks involved in practical work, as the materials and equipment used in science laboratories can be dangerous if not handled correctly. Therefore, it is crucial to prioritize safety in science laboratories and for all parties involved, including students and teachers, to understand the safety aspects of science laboratory work [3]. Ritch and Rank [4] emphasize the importance of science laboratory safety at all levels, from primary to tertiary education, and the need for awareness on the importance of prioritizing safety in science laboratories due to the frequent occurrence of accidents in such environments around the world.

The Malaysia Ministry of Education (MOE) has published the School Science Laboratory Management and Safety (SLMS) guidebook. This guidebook, first published in 1987 and revised in 1999 and 2010, aims to improve the quality of school science laboratories and equip school administrators and teachers to handle issues related to their management [5]. The SLMS guidebook covers two main management fields, including the management of science laboratories and laboratory safety. Moreover, the national science curriculum emphasizes the need for increased laboratory safety, with improved textbooks and science-based practical workbooks that include icons such as warning signs and precautionary measures for every experiment. These efforts highlight the MOE's commitment to science education and demonstrate that school science laboratory safety is taken seriously. The traditional instructional method of science laboratory safety was implemented via verbal explanation from educators using laboratory manuals with 5 to 10 pages which are too complex to comprehend without additional summarized information. Consequently, the level of knowledge and exposure to workplace safety in science laboratories among secondary school students is still low, despite the availability of the SLMS guidebook [6].

Comic strips have been proven to increase students' interest and awareness of safety in chemistry laboratories [7]. Comics have been widely utilized for educational purposes, as they make the teaching-learning process more engaging and entertaining. Researchers have also investigated whether comics have direct benefits in the instructional process, leading to the identification of three main uses of comics and caricatures: as a warm-up activity, as an instructional tool, and as an assessment tool. Comics are a suitable learning tool for economically and educationally disadvantaged children [8]. Moreover, Özdemir [9] and Heller [10] highlighted the advantages of comics in effectively communicating information, simplifying instructions, promoting discussions, and enhancing cognitive retention as a mnemonic tool.

However, to develop an educational comic that can meet students' needs, a needs analysis must be conducted to identify the requirements for developing the science laboratory educational comic on improving science laboratory safety awareness among secondary school students as well as to see students' awareness and knowledge towards science laboratory safety. Therefore, this study was conducted to meet those objectives. The research objectives are: i) to identify students' awareness and knowledge towards science laboratory safety and ii) to investigate the needs for developing the educational comic on science laboratory safety among secondary school students.

2. METHOD

2.1. Research design

This study is quantitative research that employs survey research design. The survey research is defined as the utilization of surveys, which researchers distribute to respondents, as a means to conduct research [11], [12]. Surveys are widely recognized as the predominant form of quantitative research, enabling the collection of data from a broad audience across diverse sources [13]. This survey study uses questionnaires as a medium to obtain data from respondents. By utilizing structured questionnaires, surveys facilitate the collection of standardized data. Furthermore, this quantitative research design ensures respondent anonymity and confidentiality, fostering candid and truthful responses [14].

2.2. Population and sampling

The sample chosen for the implementation of this study consists of secondary school students across Malaysia. The sample was selected using simple random sampling. In this sampling method, the sample is selected randomly and by chance, ensuring that the quality of the sample is not compromised because each member of the population has an equal chance of being selected as a sample [15], [16]. Only 131 secondary school students voluntarily participated in this study by completing a questionnaire in the form of a Google Form. This Google Form was shared within the respective student WhatsApp group. Students filled in the questionnaire using their mobile devices, and the statistics were monitored within the Google Form application. The effectiveness of conducting this online study will be supported by van Selm and Jankowski [17], who state that when most of a society has internet access and savvy, the basic drawback for the use of online survey research, the lack of representativeness, will disappear. The internet was an even more valued

tool to obtain information from respondents living in different parts of a country or around the world, simply and at a low cost.

2.3. Instrumentation

The research instrument takes the form of a questionnaire adapted from the literature studies [18], [19]. This questionnaire consists of three parts: Part A, Part B, and Part C, as shown in Table 1. Part A outlines the demographics of the respondents, such as gender, grade level, type of school, and laboratory accident experience. Part B, on the other hand, focuses on addressing the two research objectives, where items one through five list questions regarding the need for the development of a science laboratory educational comic on improving science laboratory safety awareness among secondary school students, while items six through nine are used to assess students' awareness and knowledge towards science laboratory safety. Meanwhile, Part C focuses on items in developing the science laboratory educational comic on improving science laboratory safety awareness among secondary school students.

Table 1. Details of the research instrument

Part	Component
Part A	Demography of respondents
Part B	Item 1 to item 5-students' awareness towards science laboratory safety
Part C	Item 1 to item 21-needs analysis to develop the science laboratory safety educational comic

Section B and C consist of three types of items, namely dichotomous items, Likert scale items, and open-ended question items. The Likert scale used is a five-point Likert scale as shown in Table 2. The use of this type of Likert scale is more suitable for testing the content validity of the instrument [20]–[22].

Table 2. Five-point Likert scale

Level	Score
Strongly disagree	1
Disagree	2
Neutral	3
Agree	4
Strongly agree	5

2.4. Validity and reliability

After the instrument was developed, two experts in the field were appointed to conduct validation on the questionnaire [23]. The validation experts comprise a science educational module expert, namely an education lecturer, and an outstanding science teacher. The instrument subsequently underwent analysis and refinement according to the comments and suggestions from the experts as shown in Table 3.

Table 3. Comments and suggestions from experts

Expert	Comments and suggestions
Expert 1	Overall, it is good and appropriate. However, there is repeated item (refer to the instrument): directly focus on the topic (item no. 7)
Expert 2	The research instrument produced is excellent. The presented ideas are original, have high validity, the language used is appropriate for the students' level, and it is systematically organized. This module is highly suitable for future use

Furthermore, to determine the agreement value of face validity and content validity among experts, the content validity index (CVI) was utilized. For new instruments, the CVI value to be achieved is ≥0.8 [24]. The implementation of CVI technique is considered valuable for researchers for items screening empirically in instruments through quantitative research. It ensures that each item accurately represents the content domain of the construct, helping to decide whether to retain or discard items [25]. In this study, CVI was analyzed according to the (1) as well as (2) and CVI values were recorded in Table 4.

$$Content\ validity\ index\ (CVI) = \frac{Total\ of\ scores\ each\ expert}{Total\ of\ real\ score} \quad (1)$$

$$Item\ level\ validity\ index\ (I-CVI) = \frac{Number\ of\ items\ agreed}{Number\ of\ experts} \quad (2)$$

Table 4. Comments and suggestions from experts

Construct	Item	Expert 1	Expert 2	I-CVI
Face validity	Item 1	1	1	1
	Item 2	1	1	1
	Item 3	1	1	1
	Item 4	1	0	0.5
	Item 5	1	1	1
	Item 6	1	1	1
Total CVI		1.0	0.83	0.92
Content validity	Item 1	1	1	1
	Item 2	1	1	1
	Item 3	1	0	0.5
	Item 4	1	1	1
Total CVI		1.0	0.75	0.875

The average I-CVI score for face validity is recorded as 0.92, while the average I-CVI score for content validity is recorded as 0.875. This indicates that the CVI values for each construct meet the accepted CVI criteria [24], which is a CVI value ≥0.8. After ensuring that the questionnaire is suitable for use, the instrument was distributed to the respondents via WhatsApp and email. Reliability, which pertains to the consistency of measurements, ensures that the outcomes from participants using an instrument designed to gauge depression, for instance, remain relatively consistent each time the test is administered in the future. The Kuder-Richardson Formula 20 (KR-20) is employed to assess reliability for test instruments involving binary variables (0 and 1), where responses are either true or false, right or wrong, and yes or no [26]. In this study, the reliability value is determined to be 0.88, as in Table 5. McGrath suggests that low test reliability is anticipated in concept inventories when the content proves excessively challenging or straightforward for respondents to comprehend [27]. This proves that the questions asked in the survey forms in this study were clear and easy to comprehend.

Table 5. Test reliability using Cronbach's alpha

Cronbach's alpha	N of items
.88	29

2.5. Data collection procedure

Data collection is the process of gathering relevant information to address the research questions of this study [28], [29]. To collect data, a questionnaire for needs analysis was distributed to 131 secondary school students in the science-streamed classes across Malaysia. The questionnaire was distributed to each respondent using Google Forms, allowing them sufficient time to complete it based on their awareness and knowledge towards science laboratory safety, and developing the science laboratory educational comic. The questionnaire solely focuses on questions relevant to the research, ensuring the study's main purpose is maintained. The responses were analyzed, with each item scrutinized, and the total marks were tallied across respondents. The findings from this analysis will address the research questions, leading to conclusions and recommendations discussed towards the end of the study.

2.6. Data analysis

Data analysis was conducted descriptively, using frequencies and percentages. The collected data were analyzed using SPSS version 23.0 software. The Likert scale used was assigned scores to facilitate calculation. The scale of strong disagreement was assigned a value of one, while the scale of strongly agree was assigned a value of five. For the analysis of items using a five-point Likert scale, mean score values for the items were calculated based on Landell's mean score value and levels as stated in Table 6. All responses received were analyzed to derive conclusive findings.

Table 6. Mean score values and levels based on [30]

Mean value	Level
1.00-2.33	Low
2.34-3.67	Moderate
3.68-5.00	High

3. RESULTS AND DISCUSSION

3.1. Analysis of distribution of demography for research respondents

The demographic distribution analysis of the study respondents is recorded in Table 7, involving gender, age, ethnicity, and school type. The results of the descriptive analysis by percentage indicate that the respondent distribution is nearly equal, with male students comprising 48.1% and female students 51.9%. Examining the age distribution, most survey participants are from form three (equivalent to grade 9 which typically aged 15 in the Malaysian secondary school system) (40.5%), predominantly Malay (52.7%). Furthermore, considering the school type, the data distribution reveals that the highest percentage of respondents comes from national secondary schools (SMK) or national-type secondary schools (SMJK), accounting for 66.4%.

Table 7. Total percentages of demographics respondents

No.	Items	Category	Frequency	Percentage (%)
1	Gender	Male	63	48.1
		Female	68	51.9
		Total	131	100
2	Age	13 years old	46	35.1
		14 years old	32	24.4
		15 years old	53	40.5
		Total	131	100
3	Race	Malay	69	52.7
		Chinese	31	23.7
		Indian	11	8.4
		Bumiputera	20	15.3
		Total	131	100
4	School	*Sekolah Berasrama Penuh* (SBP)	8	6.1
		Maktab Rendah Sains MARA (MRSM)	1	0.8
		SMK/*Sekolah Menengah Jenis Kebangsaan* (SJK)	87	66.4
		Others	35	26.7
		Total	131	100

3.2. Analysis of students' awareness towards the science laboratory safety in school

The findings for item 1 indicate that a minimum score of 3.62 was obtained as in Table 8. This suggests a moderate level of awareness of laboratory safety regulations, with only 70 (53%) out of 131 respondents aware of the existence of safety regulations in the laboratory. A total of 67 (51%) respondents with a mean score of 3.54 expressed difficulty in understanding all safety regulations easily, while 71 (54%) respondents stated that they adhere to all established laboratory safety regulations. These findings also show that 76 (58%) and 63 (48%) respondents are aware that they need to comply with safety instructions given and understand that failure to adhere to established safety regulations could result in accidents for themselves and their peers. Overall, the awareness level of safety in the laboratory is moderate with an average mean score of 3.53. These findings clearly indicate that, on average, respondents are still not fully aware of the importance and compliance with laboratory safety. The findings are likely driven by factors such as a lack of clear understanding of existing regulations and an attitude that does not take laboratory safety seriously. Although these figures do not represent all students at secondary schools across Malaysia, the findings clearly indicate that the level of awareness of regulations in the laboratory among average students is still low and needs to be improved. Additionally, based on an average mean score of 3.53, it was found that this awareness level is not influenced by age and level of form factors.

Table 8. Findings for level of awareness towards the science laboratory safety

No.	Items	Mean	Level
1	I know that there are safety rules in the laboratory	3.62	Moderate
2	I easily understand all the safety rules in the laboratory	3.54	Moderate
3	I follow all the established laboratory safety rules	3.51	Moderate
4	I know I need to follow the safety instructions given while in the laboratory	3.65	Moderate
5	I understand that failing to comply with the established safety rules can lead to accidents for me and my colleagues	3.31	Moderate
	Average mean score	3.53	Moderate

3.3. Analysis of needs to develop the educational comic for science laboratory safety

There are 12 items adapted and adopted from [31] and [32] to assess the needs in developing an educational comic on science laboratory safety. These items consist of students' perceptions of the

requirements for the development of educational comics, as in Table 9, and appropriate methodological approaches are incorporated in the development of educational comics on science laboratory safety to meet the preferences of high school students, as in Table 9. In examining students' perceptions of the need for developing educational comics on science laboratory safety, the analysis of item 1 showed a mean score of 3.38, indicating a moderate level that respondents read comics. Meanwhile, the item 2 showed a higher level of mean score which is 3.68, indicating the respondents prefer to read the educational comics. Apart from that, high level of mean scores with the range value of 3.68 to 4.23, indicating that the respondents agreed that the educational comics could offer various significant benefits i.e., reduce stress, enjoy, stimulate thinking skills, convey good moral values and religious understanding, assist to memorize facts and complex technical concepts. In fact, the educational comics were highly agreed to be used as science learning materials, and reference materials for science laboratory safety with the mean scores of 3.95 and 4.10 respectively. Therefore, from the analysis of Table 9, it can be concluded that most respondents, with a mean score of 3.90 (indicating a high level of mean score), provided positive responses towards the development of an educational comic for science laboratory safety.

Table 9. Aspects of need to develop the educational comic for science laboratory safety

No.	Items	Mean	Level
1	I read comics	3.38	Moderate
2	I read educational comics	3.68	High
3	Reading comics helps reduce stress in my daily routine	3.82	High
4	Reading comics is enjoyable	4.14	High
5	The nature of comics, with less text and messages easily conveyed through sequential picture frames, makes me prefer reading comics over novels, general books, and others	3.77	High
6	The messages conveyed in the comics I read can stimulate my mind and thinking skills	3.88	High
7	Educational comics produced can be a scholarly reference for readers	4.23	High
8	Educational comics can teach good moral values and religious understanding	4.10	High
9	Educational comics help me remember and memorize facts more effectively	3.93	High
10	Educational comics assist me in understanding complex technical concepts	3.84	High
11	Educational comics are suitable to be used as science learning materials	3.95	High
12	Educational comics are suitable to be used as learning/reference materials for science laboratory safety	4.10	High
	Average mean score	3.90	High

Furthermore, to develop an educational comic on science laboratory safety that aligns with students' needs, items in Table 10 were developed and responded to by the respondents. These items encompass learning approaches in educational comics on science laboratory safety that are suitable for inclusion in the intended educational comic. Based on Table 10, an approach with more than five pages received a high mean score of 3.72, as chosen by the respondents. They tend to prefer educational comics that can improve understanding and memory in learning, with a notably high mean score value of 4.27. Most respondents agree that they prefer science learning materials in the form of comics (with a high mean score of 3.82) because educational comics supported by images and photos provide a better understanding of science concepts, as indicated by a high mean score value of 4.28. Additionally, respondents concur that content selection should include more detailed academic facts, depict Malaysian culture, and maintain a balance between academic facts and storytelling, reflected in mean score values of 3.79, 4.05, and 3.82, respectively. From the analysis of Table 10, it is evident that most respondents agree that emphasis should be placed on content and technical approaches in educational comics to develop a science laboratory safety educational comic that suits the needs of students, with a high average mean score of 3.73.

Table 10. Aspects of criteria to develop the educational comic

No.	Items	Mean	Level
13	I prefer reading educational comics with short and less dense pages (1-2 pages only)	2.73	Moderate
14	I prefer reading educational comics with moderate and moderately dense pages (3-4 pages only)	3.08	Moderate
15	I prefer reading educational comics with long and denser pages (more than 5 pages)	3.72	High
16	I am interested in reading educational comics that can help me improve understanding and memory in learning	4.27	High
17	I choose Science learning materials in comic form	3.82	High
18	I find it easier to understand Science with the help of pictures/photos	4.28	High
19	Educational comics produced detail academic facts	3.79	High
20	Comics produced must have the identity and image of Malaysia	4.05	High
21	The content of educational comics produced must be balanced in terms of academic facts and storytelling	3.82	High
	Average mean score	3.73	High

4. CONCLUSION

In conclusion, the findings of this study underscore the significance of conducting a thorough needs analysis in the design and development of educational materials, particularly in the context of science laboratory safety among secondary school students. The quantitative survey, involving 131 secondary school students across Malaysia, revealed a consensus among respondents regarding the suitability of the proposed science laboratory educational comic in addressing their needs. However, the moderate average mean score of 3.53 highlights a concerning low level of awareness regarding laboratory regulations among the surveyed students, emphasizing the urgency for improvement. Encouragingly, the high average mean score of 3.90 indicates strong agreement among respondents about the necessity of developing a science laboratory safety educational comic to enhance awareness. The study also emphasizes the importance of focusing on content and technical approaches, with a high average mean score of 3.73, signaling a consensus on the key aspects that should be prioritized in crafting an effective educational comic. Overall, the results of this study provide the need for a science laboratory educational comic on improving science laboratory safety knowledge and awareness among secondary school students.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflicts of interest to report regarding the present study

INFORMED CONSENT

Participation in this study was voluntary. All respondents were informed about the purpose of the study and agreed to participate before completing the questionnaire. The survey was conducted anonymously through an online platform, and no personal identifiable information was collected. Completion of the questionnaire was considered as informed consent to participate in the study.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [NFS], upon reasonable request. The authors confirm that all data underlying the findings are fully available without restriction.

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