

STEM Based Teaching and Learning Module Development for Year 5 Plant Topics

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Abstract

STEM is an acronym of science, technology, engineering and mathematic, it is crucial to apply STEM education in recent years of education. Teachers should have their own teaching module that suite their student's needs. The objective of this study is to create and assess the viability of an educational module for teaching and learning about plants, specifically designed for fifth-grade primary school students. The research employed the Research and Development (R&D) approach, utilizing the ADDIE model, which includes analysis, design, development, implementation, and evaluation stages. The outcomes of the research (1) demonstrate the successful creation of a teaching and learning module focused on plants for fifth-grade students. (2) The collective agreement percentage derived from the experts amounts to 90.44%. The content validity analysis of the teaching and learning module, based on the ADDIE framework, was assessed by six experts who provided a commendable score, with an average agreement percentage of 88%. (3) The reliability assessment, indicated by Cronbach's alpha coefficient, yielded a value of 0.897. The analysis of the feasibility questionnaire resulted in highly favourable scores of 90.44%. Therefore, the teaching and learning module based on the ADDIE model, focusing on the topic of plants for fifth-grade students, is deemed suitable as a learning medium for primary school students.

Keywords: STEM Education, Module Development, Addie Model

Introduction

STEM education is an acronym for education that involves the subjects of Science, Technology, Engineering, and Mathematics. In Malaysia, STEM education is a form of education that has been incorporated into the national education policy, with various government policies in place to support its implementation, such as the Malaysia Education Blueprint (MEB) 2013-2025 (Kong & Effendi, 2020). Other policies that support the implementation of STEM education in the country include the National Science, Technology, and Innovation Policy (NSTIP) and Vision 2020.

Based on the STEM education policy established by the government, the Ministry of Education Malaysia (MOE) has created various efforts to welcome this pure policy to attract student interest in STEM fields at the primary school level (Aminah Jekri & Crispina Gregory K Han, 2020). According to (Aminah & K Han, 2020), STEM education is an important education

in preparing competitive students at a higher level, where the MOE has used the MEB 2013-2025 to make STEM education an important aspect of the country's education transformation to prepare students in Malaysia to face the challenges of the 21st century. STEM education conducted by the MOE can change students' perspectives so that they are not only focused on one particular field of interest but also can utilize appropriate technologies related to their chosen fields.

In order to achieve a developed country status in line with the times, STEM education needs to be innovated to attract more students to enter the STEM field. Therefore, teachers should play an important role in realizing this effort together with the Ministry of Education (Jekri & Han, 2020). STEM education can cultivate students' minds towards being more active in solving problems (Amatan et al., 2022). Furthermore, STEM education also strives to improve scientific skills and can produce students who are active-minded and think creatively and critically (Takeuchi et al., 2020). In the effort to cultivate students to embrace STEM education, teachers are the first individuals who need to strive to introduce students to this learning culture (Nugroho et al., 2019). Teachers need to have a high willingness to carry out STEM education in schools to shape students, especially in science and math subjects, to enable them to build problem-solving skills and think at a higher level (Hallström & Schönborn, 2019). Additionally, the willingness of teachers in carrying out STEM education is expected to foster a new competitive culture among students by innovating in every aspect that students learn. Therefore, it is important for teachers to strive to build and design teaching and learning strategies that they will implement well in order to achieve the goal of STEM education (Liu et al., 2020).

The ability of a teacher to develop effective teaching and learning plans is the most important step in providing students with effective STEM education (Gao et al., 2020). Teachers should have their own teaching and learning modules, complete with daily lesson plans, activities, and relevant teaching aids to better prepare for teaching and learning sessions in the classroom (Khuyen et al., 2020). Therefore, it is a teacher's responsibility to develop their own teaching modules that are effective and to share ideas with other teachers in order to create effective teaching and learning for students in the classroom. In line with this, this study aims to develop a STEM-based teaching and learning module for Year 5 primary school science subjects in topics that teachers find challenging to implement STEM education. This study will examine which topics are difficult for teachers to incorporate STEM education in their teaching and learning and to identify the elements that teachers feel should be included in a teaching and learning module. Additionally, this study aims to provide teachers with guidance on how to develop a teaching and learning module from start to finish using the ADDIE model. The study will also assess the reliability and validity of the developed teaching and learning module but will not evaluate its effectiveness. It is hoped that this study will assist the Ministry of Education and teachers, in particular, in developing teaching and learning modules that have a high impact.

Monadology

This study focuses on the development of a STEM based teaching and learning module on the topic of plants for year 5 students using the ADDIE model. The ADDIE model comprises of five phases, namely analysis, design, development, implementation, and evaluation. In the analysis phase, 42 science teachers in the state of Penang were surveyed using a needs

analysis questionnaire to identify if there is a need to develop a teaching and learning module based on the ADDIE model. Furthermore, the questionnaire also aimed to determine the main topic to be included in the module.

Once the data was collected, the design phase commenced. This phase involves analysing the data gathered from the previous phase to determine the development needs of the module and identify the main topic to be included in the ADDIE-based teaching and learning module.

Next, in the development phase, the ADDIE-based teaching and learning module was constructed based on the main components identified in the needs analysis questionnaire.

To evaluate the developed module, content validity, usability, and reliability were tested using a questionnaire administered to six experts and 42 science teachers in Penang. The content validity questionnaire was given to six experts to evaluate the developed module, while the reliability and usability questionnaire were administered to the science teachers to evaluate the reliability and usability of the module.

Finally, in the evaluation phase, the validity, reliability, and usability questionnaires administered earlier were analysed. The results were then used to answer the research questions established in the study. This study is expected to contribute to the development of effective teaching and learning modules and to enhance the quality of education in STEM subjects for year 5 students.

Research Findings

Phase 1 ADDIE (Analysis)

The assessment phase involves a review method to identify the needs for developing teaching and learning STEM modules based on the ADDIE model for Year 5 students, and the appropriate topics to be used in the module. The respondents who participated in identifying the development needs were science teachers in Penang. To enhance the survey instrument's testing for these needs, language and content validity were tested based on expert assessments in relevant contexts. This approach is a rational validity approach, where the study only looks at the rational needs of the study (Abu Hassan et al., 2021). A pilot study was conducted with 15 science teachers to ensure that the survey accurately measures its intended purpose, and the results are presented in Table 1. The selection of sample respondents was based on their experience in teaching science in primary schools.

Table 1

The Cronbach's alpha value for each element of the survey questionnaire on needs.

No	Elements	Alpha Cronbach	Items
1	STEM Module development requirements	0.858	1
2	Contents of year 5 syllabus topics	0.847	10
3	Aspects of STEM module content	0.838	8
4	Aspects of STEM module activity	0.837	8
5	Assessment aspects of the STEM module	0.838	5
6	Aspects of the material in the STEM module	0.858	3
	Overall	0.848	57

Phase 2 ADDIE (Design)

The figure and table below present the outcomes of the needs analysis questionnaire, which was designed to evaluate the requirement for a teaching and learning STEM module based on the ADDIE model, and to review which topics would be most appropriate to include in the module. The survey was conducted with 42 science teachers in Penang Island.

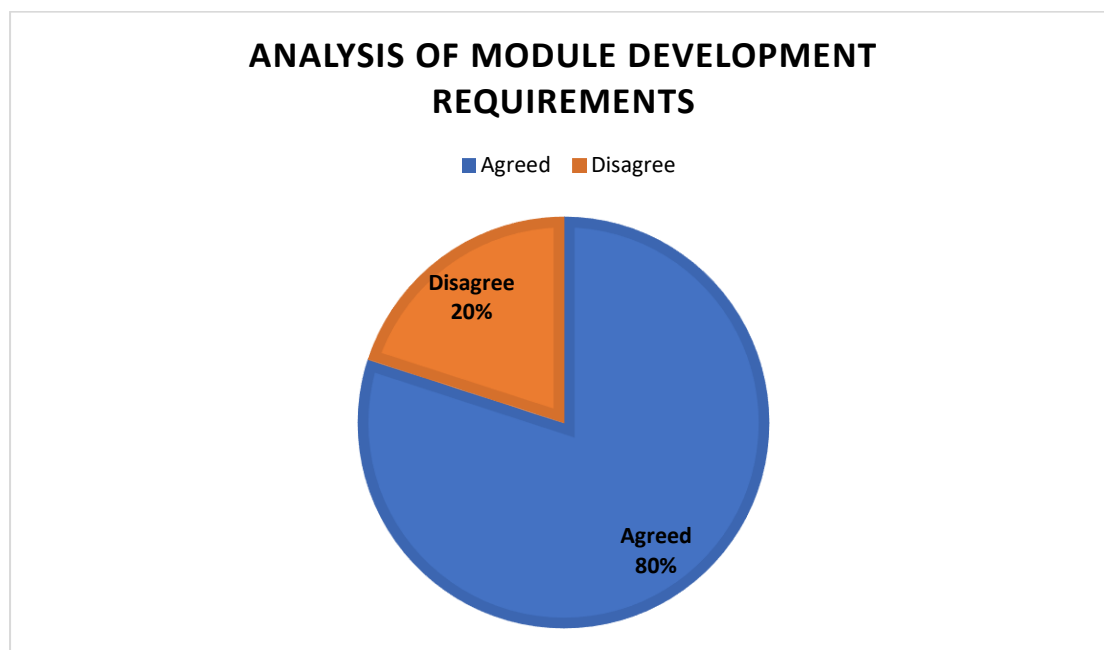


Figure 1

Analysis of teaching and learning module development needs based on the ADDIE model

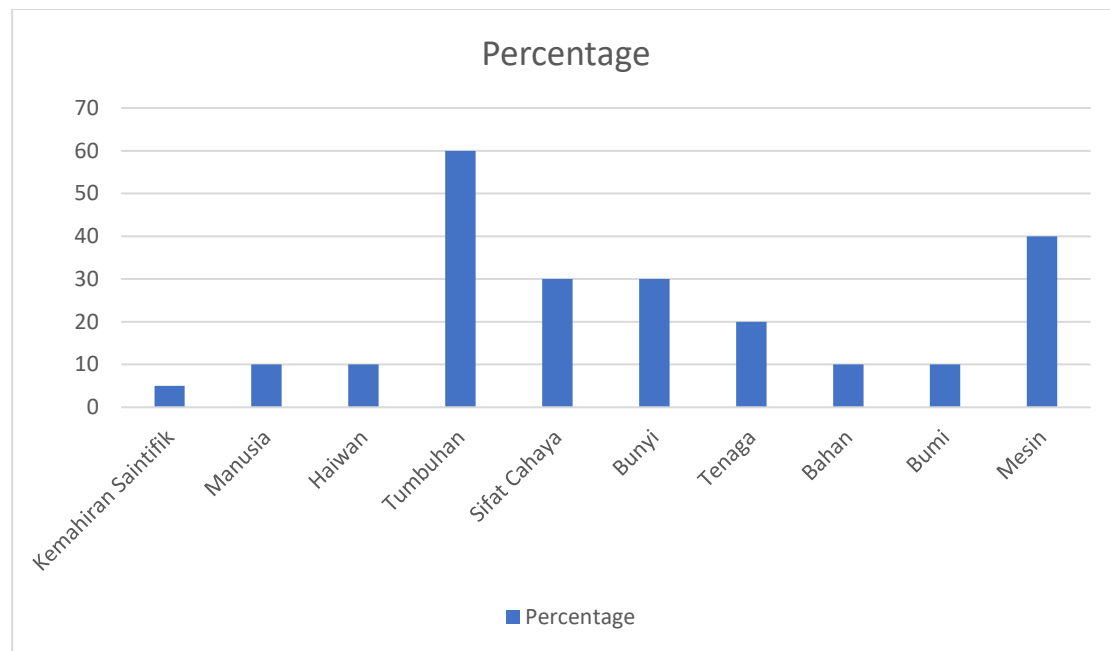


Figure 2
Year 5 Topic Requirements Analysis

Table 2
Module Content Requirements Analysis

No	Items	Percentage
1	There are module development objectives	30
2	There is a module usage guide	60
3	There is a teaching and learning guide (PdP) using active learning methods	80
4	There is a daily lesson plan (RPH)	60
5	There is a suggested time period for each activity in the module	30
6	There are student worksheets	60
7	There are examples/recommendations of materials for each activity	65
8	There are examples of results for each activity	60

Table 3

Module Activity Requirements Analysis

No	Items	Percentage
1	Students conduct experiments while PdP is actively conducted	80
2	Students communicate with friends and teachers during active lesson	75
3	Doing brainstorming activities before doing assignments	70
4	Students collect information in the form of short notes	45
5	Students perform assessment in the form of group or individual presentations	60
6	Students display the results of experiments in videos or pictures	30
7	Students share learning experiences while doing experiments	60
8	Students present and share experimental results during science lesson	65

Table 4

Analysis of Requirements Aspects of Module Assessment

No	Items	Percentage
1	Assessment is not entirely in the form of an examination	65
2	Assessment is done through the observation method	65
3	Assessment is done orally	65
4	Classroom Assessment (PBD) is done individually or in groups	85
5	Assessment in the form of project/experimental work	70

Table 5

Analysis of Material Aspect Requirements in the Module

No	Items	Percentage
1	Electronic media materials that are easy for students to print	80
2	Links from websites over the internet	70
3	Use of interactive media materials	60

According to the data presented in the figure and table above, it can be seen that 80% of the science teachers surveyed agreed that a teaching and learning STEM module based on the ADDIE model should be developed. Moreover, 60% of the teachers selected the topic of plants as the main focus of the module. The analysis of the module's content revealed that 80% of the teachers prioritized teaching and learning guidelines (PdP) using active learning methods. As for the module activity needs, 80% of the teachers preferred that students conduct experiments during active PdP. In terms of assessment, 85% of the teachers chose to include Classroom Assessment (PBD) elements, performed individually or in groups. Finally,

regarding the material aspect of the module, 80% of the teachers selected easily printable electronic materials for students. These results provide valuable insights into the needs and preferences of science teachers in Penang Island for the development of a teaching and learning STEM module on plants for Year 5 students based on the ADDIE model.

Phase 3 ADDIE (Development)

During the development stage of the module, which follows the ADDIE design model, the teaching and learning material is constructed using the primary components identified in phase 2, which is the needs analysis phase. These key components are integrated to form a comprehensive teaching and learning module that encompasses notes, directions, daily lesson plans, activities, and evaluations. The STEM-based teaching and learning module focuses exclusively on the topic of plants for the fourth grade, as determined by the needs analysis. Table 6 displays the module's content breakdown.

Table 6

Breakdown Table of Module Content Based on Year

Year	Content	Content Breakdown
5	Year 5 Plant Life Process	1. Daily lesson plans (1) and (2) 2. List of materials and apparatus 3. Activity instructions for students 4. Activity instructions for teachers 5. Assessment exercise

Phase 4 ADDIE (Implementation)

In the implementation phase, the completed teaching and learning module based on the ADDIE model will undergo an analysis to evaluate its validity, reliability, and usability. The module will be reviewed by six expert teachers to assess its suitability in terms of these factors. The survey forms used for this assessment include a content validity survey form (Appendix C) and a reliability and usability survey form (Appendix D). These survey forms were adapted from a previous study (Khalid et al., 2019). Table 7 provides a detailed breakdown of the elements and items included in both survey forms, as well as their sources from relevant literature.

Table 7

Questionnaire elements of validity, reliability and usability based on literature sources

No	Element	Items	Literature
1	Module Content Validity Questionnaire		(Khalid et al., 2019)
	1. 1. Validity of Module Content	5	
2	Module Trust and Usability Questionnaire		(Khalid et al., 2019)
	1. Demographic Information	2	
	2. Trust Module	11	
	3. Usability of the Module	45	

To assess the validity, reliability, and usability of the survey form, a pilot study was carried out to obtain Cohen's Kappa and Cronbach's Alpha values. Validity, which is defined as the appropriateness, accuracy, usefulness, and practicality of the assessment tool being evaluated, was measured according to Khalid et al (2019), who reference (Fraenkel and Wallen, 1996). The pilot study was conducted with 15 elementary school science teachers on Penang Island.

Table 8

Analysis of a Pilot Study of Module Validity, Reliability and Usability Questionnaire

No	Element	Cohen`s Kappa Value
1	Module Content Validity Questionnaire	
	2. 1. Validity of Module Content	0.83
2	Module Trust and Usability Questionnaire	
	4. Demographic Information	0.82
	5. Trust Module	0.76
	6. Usability of the Module	0.72
	Overall	0.78

Table 9

Cronbach's alpha value for each element of the validity, trust and usability questionnaire of the module

No	Element	Items	Alpha Cronbach Value
1	Module Content Validity Questionnaire		
	3. 1. Validity of Module Content	5	0.847
2	Module Trust and Usability Questionnaire		
	7. Demographic Information	2	0.820
	8. Trust Module	11	0.838
	9. Usability of the Module	45	0.898
	Overall		0.850

Phase 5 ADDIE (Evaluation)

As mentioned in the implementation phase, the finished teaching and learning module based on the ADDIE model will be evaluated to determine its validity, reliability, and usability. Six expert teachers will also be consulted to assess the module's content validity. Table 10 presents the overall results for content validity, indicating the agreement percentage of each expert and whether they agreed at a rate of over 80%.

Table 10

Achievement of Module Content Validity Based on Overall Percentage of Experts

Experts	Total Experts Score	Percentage of Agreement	Expert View
P1	20	80%	Good
P2	23	92%	Good
P3	23	92%	Good
P4	24	96%	Good
P5	23	92%	Good
P6	20	80%	Good
	Overall Average Percent	88%	

Table 11 below will detail the expert findings analysis for each item in the content validity survey form based on the expert agreement.

Table 11

Achievement of Item-Based Module Content Validity

No	Items	Total Experts Score	Percentage	Experts View
1	The content of the Active Teaching Module for the topic of plant level 2 meets the target group.	17	85%	Good
2	The content of the Active Teaching Module for the topic of plant level 2 can be implemented perfectly.	18	90%	Good
3	The content of the Active Teaching Module for level 2 plant topics corresponds to the allotted time.	18	90%	Good
4	The content of the Active Teaching Module for the topic of plant level 2 can increase students' interest in the lesson.	18	90%	Good
5	The Active Learning Module content for level 2 plant topics can help students relate the topics learned to everyday life.	17	85%	Good
	Overall Average Percent		88%	

The usability of the teaching and learning module based on the ADDIE model is also assessed to determine the percentage of agreement among experts. The module usability survey form consists of five main sections, with the number of items based on the primary components of the form explained in Table 12 below.

Table 12

Key Components of Usability Questionnaires

No	Main component	Items
1	Part A : Format	12
2	Part B: Contents	11
3	Part C : Objective Accessibility	6
4	Part D : Feasibility of PdP Process	10
5	Part E : Satisfaction	6

The usability survey form for reliability is evaluated by experts to determine the percentage of agreement on its usability. Table 13 provides a breakdown of the average agreement percentage among experts for each primary component of the usability survey form, as well as the overall average agreement percentage for the developed teaching module survey form.

Table 13

Percent Expert Agreement for Usability Questionnaires

No	Main component	Percentage of Agreement
1	Part A : Format	93.9%
2	Part B: Contents	91.1%
3	Part C : Objective Accessibility	90.5%
4	Part D : Feasibility of PdP Process	89%
5	Part E : Satisfaction	87.7%
	Average Percent Agreement	90.44%

Based on Table 13 above, the experts achieved an overall agreement percentage of 90.44%, which is considered very good and satisfactory according to Khalid et al. (2019). All of the main components evaluated in the usability survey form scored 90% or higher. This indicates that the STEM-based teaching and learning module developed has excellent usability.

Discussion***Content Validity of the Teaching and Learning STEM Module Based on the ADDIE Model***

The content validity analysis of the STEM-based teaching and learning module by 6 experts resulted in a good score with an average expert agreement percentage of 88%, which is a positive outcome. The language used in the module is appropriate for the language level and easily comprehensible, and the developed module is highly compatible with the target group. These results are consistent with the study by Khalid et al (2019), which developed a STEM-based teaching module and obtained high content validity scores. Although the subject matter of the module by Khalid et al (2019) is mathematics, the aim of both studies is the same, which is to create a module for the teaching aids purpose in PdP.

These findings are also consistent with other studies such as Ranuharja et al (2021), which developed an Interactive Learning Media module based on the ADDIE model and also showed high content validity results with a minimum percentage of 89.09%. Moreover, Chuseri et al (2021), who created a mathematics module based on High Order Thinking Skills using the ADDIE module development design model, showed that the developed module is effective in improving student achievement. Additionally, Wicaksana et al (2020) utilized the ADDIE model as a module development design model to produce an e-comic development module to increase students' interest in learning about the preparation for the independence of Indonesia. The results of their study showed that the average expert agreement percentage for content validity was high, at 78.85%.

In conclusion, based on the results presented in the previous sections, it seems that the STEM-based teaching and learning module for grade 5 plants topic is a valid and relevant study that can be used as a guide for developing modules with high validity. However, it is important to also consider the reliability and usability of the module.

Reliability of the Teaching and Learning Module Based on the ADDIE Model

The development of effective teaching and learning modules is essential to ensure students achieve the learning objectives. One of the widely used models for developing instructional materials is the ADDIE model, which consists of five stages: analysis, design,

development, implementation, and evaluation. The purpose of this study was to develop a teaching and learning module based on the ADDIE model for the Year 5 plant topic and assess its content validity, reliability, and usability.

After assessing the content validity of the module using expert reviews, the next research question to be answered was whether the developed module was suitable in terms of reliability. To assess the reliability, a reliability questionnaire was developed based on the research objectives. The Cronbach's alpha value was used to measure the reliability of the module, and the results showed a Cronbach's alpha value of 0.897, which is considered a very good value according to previous research. This indicates that the developed module has a high level of reliability and can be trusted to deliver the intended learning outcomes.

Other studies have also reported high reliability values for teaching modules developed using the ADDIE model. For example, Abu and Saleh (2020) developed a teaching module for Al-Quran using the ADDIE model and found that the reliability of the developed module was high and acceptable, with a Cronbach's alpha value of 0.838. Similarly, Khalid et al (2019) developed a STEM-based teaching module using the ADDIE model and reported a reliability value of 0.967, which is also considered a very good value.

In conclusion, the developed teaching and learning module based on the ADDIE model for the Year 4 plant topic has been found to be reliable and trustworthy, with a Cronbach's alpha value of 0.897. This value indicates that the module can be used with confidence to deliver the intended learning outcomes. The findings of this study are consistent with previous research that has reported high reliability values for teaching modules developed using the ADDIE model. The next step is to evaluate the usability of the developed module, which will be discussed in the next subtopic. It is essential to assess the usability of the module to ensure that it is user-friendly and can be used effectively by teachers and students to achieve the desired learning outcomes.

Usability of the teaching and learning STEM module based on the ADDIE model

The next objective of the study is to assess the feasibility aspect of the teaching and learning module based on the ADDIE model. To measure this aspect, a feasibility questionnaire module was used which included five main aspects such as format, content, ability to achieve objectives, feasibility of PdP process, and satisfaction. Before administering the feasibility questionnaire to the teachers, a pilot study was conducted to test its effectiveness.

The feasibility questionnaire was administered to 42 science teachers teaching in primary schools in the state of Penang. The analysis of the feasibility questionnaire showed that the values obtained were very good, with an average percentage agreement for all aspects at 90.44%. The percentage agreement based on the evaluated aspects can be found in the table provided. Based on these results, it can be concluded that the teaching and learning module based on the ADDIE model is good and suitable in terms of the feasibility aspect.

The high agreement percentage score indicates that the teaching and learning module based on the ADDIE model is feasible and can be used effectively. This result is in line with the previous research conducted by Wahyugi and Fatmariza (2021); Khalid et al (2019), which showed that the feasibility of a module is an important aspect to be considered when

developing a module. The high feasibility score indicates that the developed module is user-friendly and easy to implement in a classroom setting.

In conclusion, the feasibility aspect of the teaching and learning module based on the ADDIE model was evaluated using a feasibility questionnaire module. The results showed that the developed module is suitable and feasible for use in primary schools. The high percentage agreement score obtained in all aspects of the feasibility questionnaire indicates that the module is user-friendly and can be implemented effectively in the classroom setting. The results of this study support the use of the ADDIE model as a guide for building and developing modules that are feasible and effective in achieving their objectives.

Conclusion

To summarize, the study concluded that the teaching and learning STEM module developed for fifth-year primary school students based on the ADDIE model has been endorsed and approved by experts and is suitable for use in classroom teaching and learning. The study aimed to meet the needs of various parties, including the Malaysian Ministry of Education, teachers, and students, to facilitate more effective active learning during teaching and learning sessions. The findings can also assist teachers and educational management in learning how to develop teaching and learning modules in a better and more systematic manner. Overall, the study's results offer valuable insights into creating effective teaching and learning modules, which can benefit students and teachers alike in their educational journeys.

Contribution

The majority of participants involved in this study expressed favorable opinions regarding the quality, interest, and comprehensibility of the module. The STEM teaching and learning module, focusing on the topic of plants for fifth-grade students, holds potential as a valuable reference for teachers seeking to implement effective instructional practices. Furthermore, the module's utilization can assist teachers in optimizing their time allocation for teaching preparations, as it encompasses a comprehensive range of resources, such as daily lesson plans, notes, exercises, and assessment tests. This module indirectly contributes to improved student understanding and generates interest in the field of science. Moreover, the development of this module can serve as a guide for various educational stakeholders, including teachers, schools, District Education Offices (DEO), State Education Departments (SED), and the Ministry of Education (MOE), facilitating the planning and development of modules across diverse topics. By constructing modules that cover a wide range of subjects, schools can cultivate the creativity of both students and teachers, ultimately enhancing student and teacher motivation.

In conclusion, the development of this STEM teaching and learning module has been well-received by all parties involved and has positively impacted the quality of teaching and learning provided by educators. The implication of this module's development lies in its potential to enhance teachers' pedagogical knowledge, consequently improving their teaching practices and expanding the awareness and knowledge of science teachers. This, in turn, enables them to approach the planning and implementation of teaching and learning processes with greater creativity and critical thinking, ultimately fostering increased student interest in the subject matter. It is hoped that the development of this STEM teaching and learning module offers a clear understanding of the module development process and its

advantages, serving as a valuable point of reference for teachers, schools, District Education Offices (DEO), State Education Departments (SED), and the Ministry of Education (MOE).

Reference

- Abu, A. T., & Saleh, R. A. A. R. S. (2020). Pembinaan Modul Pengajaran al-Quran (al-Alaq) dengan Menggunakan Model Instruksional ADDIE. *BITARA International Journal of Civilizational Studies and Human Sciences Volume*, 3(3).
- Abu Hassan, S. A., Abidin, Z. S., & Hassan, Z. (2021). Keberkesanan Pembelajaran Dan Pengajaran Dalam Talian (E- Pembelajaran) Terhadap Pembelajaran Pelajar Di Kolej Komuniti Hulu Langat. *International Journal of Humanities Technology and Civilization (IJHTC)*, 2(10), 1–14.
- Amatan, M. A., Han, G. K. C., & Pang, V. (2022). Pembinaan dan Pengesahan Soal Selidik Proses Pelaksanaan STEM dalam Pengajaran dan Pembelajaran Guru. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 7(2). <https://doi.org/10.47405/mjssh.v7i2.1309>
- Aminah, J., & K Han, C. G. (2020). Pengaruh pengalaman mengajar dalam pengetahuan, motivasi dan pelaksanaan pengajaran dan pembelajaran STEM. *Jurnal Pendidikan Sains & Matematik Malaysia*, 10(2).
- Jekri, A., & Han, C. G. K. (2020). Cabaran dalam melaksanakan pengajaran dan pembelajaran STEM di sekolah menengah. *International Journal of Education, Psychology and Counseling*, 5(34).
- Chuseri, A., Anjarini, T., & Purwoko, R. Y. (2021). PENGEMBANGAN MODUL MATEMATIKA BERBASIS REALISTIK TERINTEGRASI HIGHER ORDER THINKING SKILLS (HOTS) PADA MATERI BANGUN RUANG. *Alifmatika: Jurnal Pendidikan Dan Pembelajaran Matematika*, 3(1). <https://doi.org/10.35316/alifmatika.2021.v3i1.18-31>
- Gao, X., Li, P., Shen, J., & Sun, H. (2020). Reviewing assessment of student learning in interdisciplinary STEM education. In *International Journal of STEM Education* (Vol. 7, Issue 1). <https://doi.org/10.1186/s40594-020-00225-4>
- Hallström, J., & Schönborn, K. J. (2019). Models and modelling for authentic STEM education: reinforcing the argument. *International Journal of STEM Education*, 6(1). <https://doi.org/10.1186/s40594-019-0178-z>
- Jekri, A., & Han, C. G. K. (2020). Pengaruh pengalaman mengajar dalam pengetahuan, motivasi dan pelaksanaan pengajaran dan pembelajaran STEM. *Jurnal Pendidikan Sains & Matematik Malaysia*, 10(2).
- Khalid, S. N., Musa, M., Rahmat, F., Mohamed, N. A., & Azian, N. A. A. M. (2019). PEMBANGUNAN DAN PENILAIAN MODUL PENGAJARAN STEM STEM merupakan akronim bagi Science, Technology, Engineering dan Mathematics. dalam empat bidang, iaitu Sains, Teknologi, Kejuruteraan dan Matematik dengan permasalahan dalam kehidupan seharian yang be. *Journal of Quality Measurement and Analysis*, 15(2), 25–34.
- Kong, S. F., & Effendi, M. E. M. M. (2020). Pendekatan STEM dalam proses pengajaran dan pembelajaran: Sorotan Literatur Bersistematik (SLR). *Pendidikan Sains & Matematik Malaysia*, 10(2).
- Liu, Z. Y., Chubarkova, E., & Kharakhordina, M. (2020). Online technologies in STEM education. *International Journal of Emerging Technologies in Learning*, 15(15). <https://doi.org/10.3991/ijet.v15i15.14677>

- Nugroho, O. F., Permanasari, A., & Firman, H. (2019). The movement of stem education in Indonesia: Science teachers' perspectives. *Jurnal Pendidikan IPA Indonesia*, 8(3). <https://doi.org/10.15294/jpii.v8i3.19252>
- Ranuharja, F., Ganefri, G., Fajri, B. R., Prasetya, F., & Samala, A. D. (2021). DEVELOPMENT OF INTERACTIVE LEARNING MEDIA EDUGAME USING ADDIE MODEL. *Jurnal Teknologi Informasi Dan Pendidikan*, 14(1). <https://doi.org/10.24036/tip.v14i1.412>
- Takeuchi, M. A., Sengupta, P., Shanahan, M. C., Adams, J. D., & Hachem, M. (2020). Transdisciplinarity in STEM education: a critical review. In *Studies in Science Education* (Vol. 56, Issue 2). <https://doi.org/10.1080/03057267.2020.1755802>
- Khuyen, N. T., van Bien, N., Lin, P. L., Lin, J., & Chang, C. Y. (2020). Measuring teachers' perceptions to sustain STEM education development. *Sustainability (Switzerland)*, 12(4). <https://doi.org/10.3390/su12041531>
- Wahyugi, R., & Fatmariza, F. (2021). Engembangan Multimedia Interaktif Menggunakan Software Macromedia Flash 8 Sebagai Upaya Meningkatkan Motivasi Belajar Siswa Sekolah Dasar. *Edukatif: Jurnal Ilmu Pendidikan*, 3(3).
- Wicaksana, I. P. G. C. R., Agung, A. A. G., & Jampel, I. N. (2020). PENGEMBANGAN E-KOMIK DENGAN MODEL ADDIE UNTUK MENINGKATKAN MINAT BELAJAR TENTANG PERJUANGAN PERSIAPAN KEMERDEKAAN INDONESIA. *Jurnal Edutech Undiksha*, 7(2). <https://doi.org/10.23887/jeu.v7i2.23159>