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Development of IPAS Project Modules with the 4STMD Method to Facilitate Project-Based Learning in Vocational School

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Abstract: Teaching materials are one of the important components in learning. Especially project-based learning, students really need teaching materials that can help direct their learning. This study aims to develop teaching materials that can facilitate project-based learning in the subject of science projects in vocational high schools. The research method used is research and development, namely developing teaching materials in the form of modules with the 4STMD development method which stands for Four Steps Teaching Material Development. The 4STMD method has four stages of development, namely the selection, structuring, characterization and didactic reduction stages. The ability of teaching materials to facilitate learning is carried out by reading and understanding tests on grade 10 students at one of the vocational high schools in Sumedang Regency, West Java. Based on the results of the readability test by students, 97.9% stated that the module was easy to read, while the results of the understanding test showed that 84.5% stated that the module was easy to understand. The results of the readability and understanding tests showed that most of the text in the module was easy to understand by users, namely students. The results of the study can be concluded that teaching materials with the 4STMD method can facilitate project-based learning in the science project in vocational schools.

Keywords: 4STMD method; IPAS project; Project-based learning; Teaching material

Introduction

One of the learning models currently recommended in the learning process is project-based learning (He et al., 2023; Muzana et al., 2021; Tian et al., 2023). This learning model is designed to help students understand basic concepts while honing problem-solving skills through the implementation of structured and meaningful projects. In its implementation, students are placed as active subjects who are directly involved in the contextual learning process, with an emphasis on the process of recognizing problems, investigating solutions, exploring basic concepts, designing, making, and testing real products that are oriented toward solving problems in the real world.

Learning based on the project's various advantages makes it effective in supporting successful learning. Approach This not only develops an understanding of conceptual students but also fosters skills in studying the 21st century, such as the ability to communicate, collaborate, think critically, integrate information, as well as Study independently (Tian et al., 2023). Furthermore, this model is capable increase the activeness and independence of students (Nurmiati et al., 2023), as well as pushing the self-efficacy of students in finish issues, especially in context learning physics (Samsudin et al., 2020). Learning based on projects has proven capable increase results in learning and skills think critical vocational school students (Suyono et al., 2025), as well as pushing the emergence of creative and

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innovative ideas (Yunita et al., 2025). In addition, the approach is capable create experiences that learn more meaningful, increasing retention of knowledge, and help the student apply the concept that they learn in life every day (Putra et al., 2025). The Advantage is potential collaboration and cross-discipline knowledge Because a project can be analyzed from various corners view science (Almulla, 2020).

In general, theoretical, learning based on project promising improvement quality of process and results Study students. However, at the level of implementation in the field, this model No always easy implemented. Its success depends heavily on careful planning, support flexible curriculum, as well as environment supportive learning (He et al., 2023). Susiloningsih et al. (2025) highlighted a number of frequent challenges appear, such as limitations means infrastructure, quality source Power human resources, suboptimal teacher training, and curriculum that is still nature stiff.

In context Independent Curriculum, subjects lesson Project Knowledge Natural and Social Sciences (IPAS) in Vocational Schools is one of the eye lessons that are explicit demand approach learning based on project. IPAS is designed for push student investigate problem real in the environment around and search solution through a systematic scientific process. Learning in eye lesson This integrate various element material for reach competence contextualized main in accordance with field skill students (BSKAP, 2022). This is aiming for grow a sense of curiosity know to phenomenon around and push understanding integrated conceptual with life real (Hidayah et al., 2024).

However Thus, the results studies' introduction against 41 science teachers in the Java Island region showed that implementation learning based on project Still face constraint big, especially related availability appropriate teaching materials. In the learning process, the existence of three component main — students, teachers, and teaching materials — are One unity that is not can separated. The teacher plays a role as facilitator in accompany the learning process, while functional teaching materials as the main media for help student understand concept, follow instructions, and learning in a way independent (Darmilah et al., 2023). Therefore that, availability designed teaching materials in a way creative, relevant and appropriate with characteristics student become very important.

Availability equipped teaching materials with clear and easy visualization understood very helpful vocational high school students in understand science concepts that tend to abstract (Muskania et al., 2024). Unfortunately, the source available learning moment this still not yet enough support improvement students' scientific literacy, and presentation material in textbooks often no in accordance with level understanding students (Avikasari et al., 2018). In fact, teaching materials have role strategic in science learning in vocational schools, which is ideal implementation oriented the concept of science in the world of work and industry (Agussuryani et al., 2022). Teachers basically expected capable develop appropriate teaching materials with need students, but limitations time, lack of skills write and manage technology, as well as low motivation become inhibitor in the process.

Respond problem said, various study has done for develop teaching materials based on project with approach innovative. Sahjat et al. (2025) developed an e-book that integrates learning based on project with Profile Pancasila students, who are proven capable increase thinking critical, creativity, and ability collaboration. Tartiyoso (2025) shows that use of e-modules STEM based in significant capable increase ability reasoning scientific and skills to design experiment. Wisdayana et al. (2025) also showed that teaching materials based on Socio-Scientific Issues (SSI) effective in increase science literacy and skills think critical student.

In learning based on project, the most appropriate teaching materials is module, because its nature can used in a way independent and structured. Teaching modules must be prepared by teachers or project teams before implementing the learning process in order to run optimally. The modules are designed so that students can Study Alone with minimal guidance from teachers (Thoib & Bahtiar, 2021), so it is very suitable for support implementation project in science learning. Developed modules with approach integrative has also been proven effective, such as e-modules based on teaching factory (Okterina et al., 2025), teachers need to design and develop IPAS project teaching modules that can improve creativity and mastery of concepts for vocational high school students, as well as combined modules with video media to make it easier to understand practicum (Muntari et al., 2023; Syah et al., 2019).

For answer challenge implementation Independent Curriculum, especially in IPAS context that requires approach cross discipline and contextual, is needed development systematic and adaptive teaching materials. One of the appropriate method is 4STMD (Four Steps Teaching Material Development) developed by Anwar (2023). This method consists of on four stage systematic and has proven relevant in development contextual and based teaching materials projects. A number of studies previously show that e- module 4STMD based worthy used for learning chemical and appropriate with demands curriculum as well as principal science (Faizah, 2022; Husna et al., 2022; Saputri, 2023).

Study This own important novelty Because develop teaching materials in the form of module IPAS based project 4STMD (Four Steps Teaching Material Development) method, an approach that is still seldom applied in a way specific in learning cross discipline at the vocational school level. This module developed for answer need learning that is not only emphasize mastery concepts, but also science process skills, problem solving problems, and involvement student in a way active in projects contextual. The 4STMD method offers stages systematic development, starting from identification need learning, design Contents based on context vocational, drafting integrative material, up to evaluation implementation module in a way directly. With approach This teaching material is not only valid in content, but also relevant with the real world, supporting applied learning, as well as easy implemented by teachers and used in a way independently by students.

Furthermore, development module 4STMD -based IPAS projects are also an important strategy for answer challenge implementation Independent Curriculum which emphasizes learning based on projects and integration cross discipline. During this, availability structured and contextual science teaching materials still very limited, especially those who can bridge between scientific theory and its applications in field skill vocational high school students. This module designed No only for increase applied scientific literacy, but also for grow character Pancasila students through activity collaborative, explorative, and reflective. In addition, the module This allow integration between science, technology and issues content relevant social with life students, at the same time push skills 21st century like think critical, creativity, communication, and collaboration. With Thus, the results study This expected can give contribution concrete in development innovative teaching materials that are not only strengthen quality science learning, but also improve readiness student face global challenges and the future world of work.

Method

The research method used is development research. Development research contains systematic steps in developing and perfecting products (Jalinus et al., 2021). In this study, the development of teaching materials was carried out using the 4STMD method from Sjaeful Anwar. The 4STMD method consists of four stages of development, namely the selection stage, the structuring stage, the characterization stage and the didactic reduction stage (Anwar, 2023).

Each stage in the 4STMD method has criteria so that each stage has its own instrument. The development stages in the 4STMD method must not be reversed or randomized. This means that when we compile the selection stage, it must be completed and reviewed by a 4STMD expert before entering the next stage. The instruments used are the instruments found in each stage of 4STMD development, namely:

Table 1. Instruments of compliance with the curriculum

No.	Competency Achievement	Competency Achievement Indicator (IPK)	Concept Label (LK)
...	...	...	...

Table 2. Concept/material development instruments

No.	Concept Label	Concept/Material Description	Source
...	...	...	...

Table 3. Context instruments related to context/substantial context

No.	Material Description	Substantive Context	Description of Substantive Context Development
...	...	...	...

Table 4. Module readability and understandability test instrument

Texts that will be tested for students' understanding and readability	
Text understandability	
Easy	Difficult
If it is easy, write down the main idea of the text above (students are asked to write down the main idea of the text)	Main idea: ....
If it is difficult, write down the reasons why the text is difficult.	Reason: ....

Table 5. Criteria for understanding text in the module

The number of students who filled in the main idea correctly (%)	Category
≤ 50	Difficult
50 >	Easy

Table 6. Didactic reduction in difficult texts

Material (Text)	Difficult			Types of Reduction
	Abstract	Complex	Complicated	
…	…	…	…	…

The sample in the readability and comprehension test was conducted on 10th grade students at one of the vocational high schools in Sumedang Regency, West Java Province. The number of students involved in the readability and comprehension test was 24 people to read and understand the main ideas in the teaching materials of the science project module. Meanwhile, the instrument review for each stage of the 4STMD was carried out directly by 4STMD experts and material experts.

Data collection was carried out through the distribution of readability and comprehension test instruments by students, then a recapitulation of the readability and comprehension test results was carried out. After that, an analysis was carried out by calculating the percentage of students' opinions about the text and the percentage of students who could write the main idea correctly.

The results of the analysis of the comprehension and readability test are details of easy and difficult texts for further analysis of difficult texts that are characterized as abstract, complex or complicated texts. After obtaining the characteristics of difficult texts, didactic reduction is carried out on each difficult text.

Results and Discussion

This study focuses on how to develop learning materials in the form of an IPAS project module using the 4STMD method in order to facilitate project-based learning. Therefore, this study will describe how each stage of 4STMD is carried out in the development of the IPAS project module. The development of a project-based IPAS module aims to produce a module product that is presented and arranged based on the syntax of the Project-Based Learning (PjBL) learning model (Purwoko & Bachtiar, 2022).

Selection Stage

The first thing to do in the selection stage is to conduct a review of the Science Project Learning Outcomes contained in the independent curriculum for vocational high schools (SMK). This review of learning outcomes is used to determine themes or projects that can lead to learning outcomes.

The theme or project to be carried out must refer to the aspects of the learning achievements of the Science project in the Merdeka curriculum. Aspects in the learning achievements of the Science project consist of aspects of living things and their environment, substances and their changes, energy and their changes, earth and space, space and connectivity between space and time, interaction, communication, socialization, social institutions and social dynamics, as well as economic behavior and welfare and linking these phenomena with technical skills in their field of expertise (BSKAP, 2022).

The IPAS project module in this study is used for automotive light vehicle engineering vocational studies so that the themes or projects used in the module will be associated with the vocational studies. Review of learning outcomes and project themes in the IPAS project module can be seen in Table 7.

Table 7 shows that not all aspects must be included in one project. One theme or project can contain two or more aspects. As in Table 7, Project 1 only contains aspects of energy and its changes and aspects of interaction, communication, socialization, social institutions, and social dynamics. While Project 2 contains three aspects, namely living things and their environment, substances and their changes, and economic behavior and welfare.

Table 7. Study of learning achievements of the science project subject in Vocational High Schools

Learning Outcomes	Learning Activities/Projects	Related Aspects
At the end of phase E, students are able to understand scientific knowledge and explain phenomena that occur in their surroundings accompanied by evidence. In addition, students are able to design and evaluate scientific investigations with proper procedures, interpret data and evidence scientifically by linking technical skills to their field of expertise.	Project 1: Use of technology in designing vehicle safety systems.	Physics Science: Energy and Its Changes. Social: Interaction, communication, socialization, social institutions, and social dynamics.
	Project 2: Engineering an environmentally friendly cleaning product	Biology Science: Living Things and Their Environment. Chemistry Science: Substances and Their Changes. Social: Economic Behavior and Well-being

After reviewing the learning achievement aspects related to the theme or project, the next step is to develop competency achievement indicators and concept labels. An example of the results of developing competency achievement indicators and concept labels in the IPAS project module is shown in Figure 1.

Kegiatan Belajar/Proyek	Capaian Pembelajaran	Indikator Pencapaian Kompetensi (IPK)	Label Konsep (LK)
KB 1. Proyek Sistem Pengaman Kendaraan	• Peserta didik mampu memahami pengetahuan ilmiah dan menerapkannya atau membuat prediksi sederhana disertai dengan	1) Peserta didik mampu menyelidiki fenomena kasus pencurian kendaraan bermotor yang semakin meningkat dikaitkan dengan sistem pengaman kendaraan. 2) Peserta didik mampu menjelaskan alasan	✓ Sensor ✓ Gelombang Elektromagnetik ✓ Listrik tegangan dan arus AC/DC ✓ rangkaian listrik ✓ Resistor ✓ Kapasitor

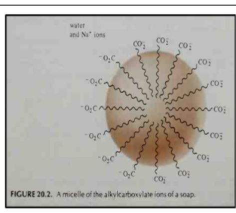
Figure 1. Example of a table for developing competency achievement indicators and concept labels

Figure 1 shows the process of concept derivation from competency achievement indicators. Concept labels are the names of concepts or sub-concepts that will be studied by students in the IPAS project module.

The next stage after we can describe the competency achievement indicators and concept labels is to describe the explanation of the concept/material from the concept label that comes from a trusted source. Here is an example of a table of descriptions of concepts/materials from each concept label in the IPAS project module.

No.	Label Konsep	Uraian Konsep/Materi	Sumber
6	Energi listrik	Energi dinyatakan dalam joule sebagai satuan SI nya. Adapun satuan lain yang menyatakan energi yaitu kalori. 1 kalori = 4,2 joule 1 joule = 0,24 kalori Hukum Kekekalan Energi menyatakan energi total sebuah sistem dan lingkungannya tidak berubah. Bila energi sistem berkurang selalu ada pertambahan energi yang terkait dengan lingkungannya atau sistem lain. Energi ada di sekitar kita dan dalam berbagai bentuk, seperti energi kinetik, energi potensial, energi listrik, energi kimia, dan sebagainya. Pemahaman tentang energi sangat penting karena energi memainkan peran penting dalam berbagai fenomena alam.	 Tipler, Paul A. (1998). Fisika Untuk Sains dan Teknik. Jakarta: Penerbit Erlangga.

(a)

No.	Label Konsep	Uraian Konsep/Materi	Sumber
4	Sabun sebagai Pengemulsi	**Teks Asli**  *A molecule of a soap contains a long hydrocarbon chain plus an ionic end. The hydrocarbon portion of the molecule is hydrophobic and soluble in nonpolar substances, while the ionic end is hydrophilic and water-soluble. Because of the hydrocarbon chain, a soap molecule as a whole is not truly soluble in water. However. soap is readily suspended in water*	Fessenden, R. J., & Fessenden, J. S. (1982). *Organic Chemistry, Second Edition.* Massachusetts: PWS Publisher.

(b)

Figure 2. (a) Example of a table for developing competency achievement indicators and concept labels in project 1, (b) Example of a table for developing competency achievement indicators and concept labels on project 1

Figure 2.a shows an example of the breakdown of concept labels in project 1, namely the concept of electrical energy obtained from a trusted reference book or the main physics textbook Paul A. Tipler. Figure 2.b shows an explanation of the concept of soap based on sources from international textbooks by Fessenden RJ and Fessenden JS.

Explanations of concept labels from trusted sources will guarantee the scientific truth of the concept. In addition, each concept written in the module has credibility with the existence of trusted references such as international textbooks. Next, after selecting reference sources, is to conduct a substance context analysis and a pedagogical context analysis. Substance context analysis is a way to connect concepts with phenomena or facts. While the pedagogical context is how to deliver students to understand concepts. Here are examples of substance context analysis and pedagogical context.

Table 8. Results of the substance context analysis in the IPAS project module

Material Description	Substantive Context	Description of Substantive Context Development
DC (Direct Current) electricity is a type of electric current that flows in one fixed direction from the positive pole to the negative pole. Different from AC (alternating current). DC power sources provide electrical energy in the form of direct current. One example of a DC power source is a battery and accumulator.	 Car battery Tips, Aftersales (2023, June 22). Understand the Function of Car Batteries, Not Just to Start the Car Engine. Retrieved on February 22, 2025, from https://www.toyota.astra.co.id/corporate-information/news-promo/read/paham-fungsi-aki-mobil-tidak-sekadar-buat-nyalain-mesin-mobil	The car battery functions to store electrical energy and supply electricity to various car systems and components. The car battery also functions to start the vehicle's engine and provide power to electronic systems, such as lights, fans, radios, and others. The battery is a source of DC electric current. When the engine is off, a very large electric current supply is needed to operate the starter motor. Once the engine is running, the alternator replaces the role of the electricity provider. When the car engine is running, the alternator will replace the role of the battery as a provider of electrical energy, as well as being used to charge electrical energy into the car battery. The electrical energy produced will be stored in the car battery by converting the incoming electrical energy into chemical energy.

Material Description	Substantive Context	Description of Substantive Context Development
		In addition to being a supply of electrical energy, the battery also acts as a stabilizer of electrical voltage. Electrical components in cars generally use a voltage of 12 volts. While the charging system (alternator) will produce a voltage of more than 12 volts, ranging from 13 volts to 14.3 volts when working.

Structuring Stage

The second stage of the 4STMD method is the structuring stage. At this stage we create a framework for teaching materials or modules. Teaching materials must be arranged in such a way that it is easy for users, both students and teachers, to learn them. In the structuring stage there are three jobs, namely creating concept maps, macro structures and drafts of teaching materials.

The concept map in the IPAS project module is adjusted to the selected project. For the concept map in project 1, it can be seen in the following image.

The next stage is to create a macro structure. The macro structure becomes our reference in arranging the teaching materials. The Figure 4 is the result of the macro structure arrangement activity for the IPAS project module.

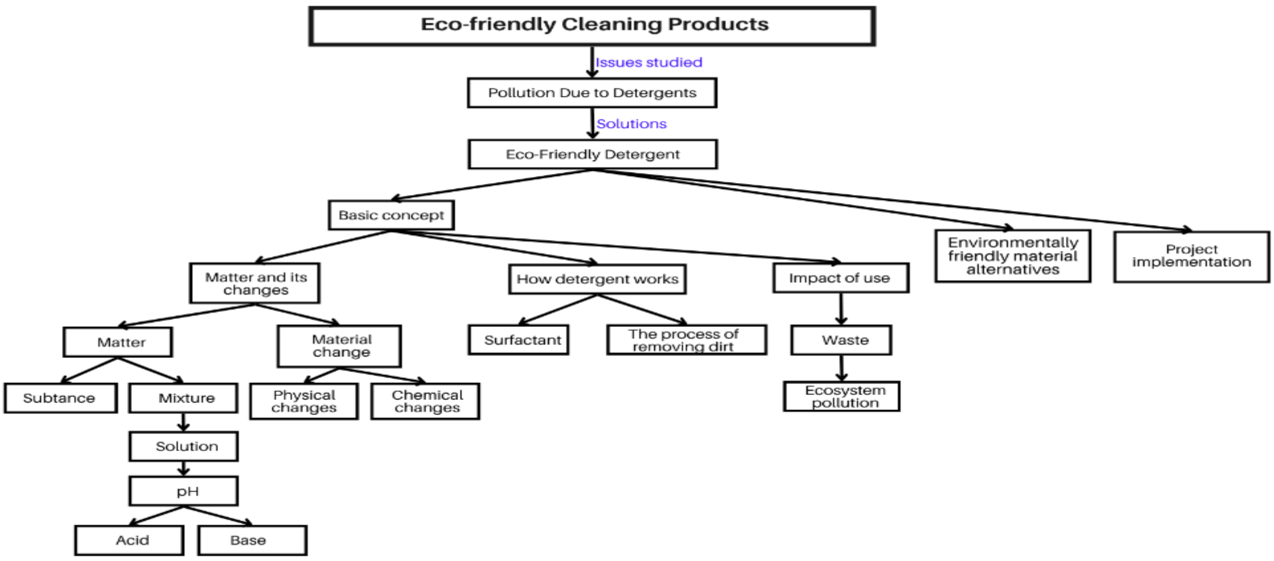


Figure 3. Project concept map 2

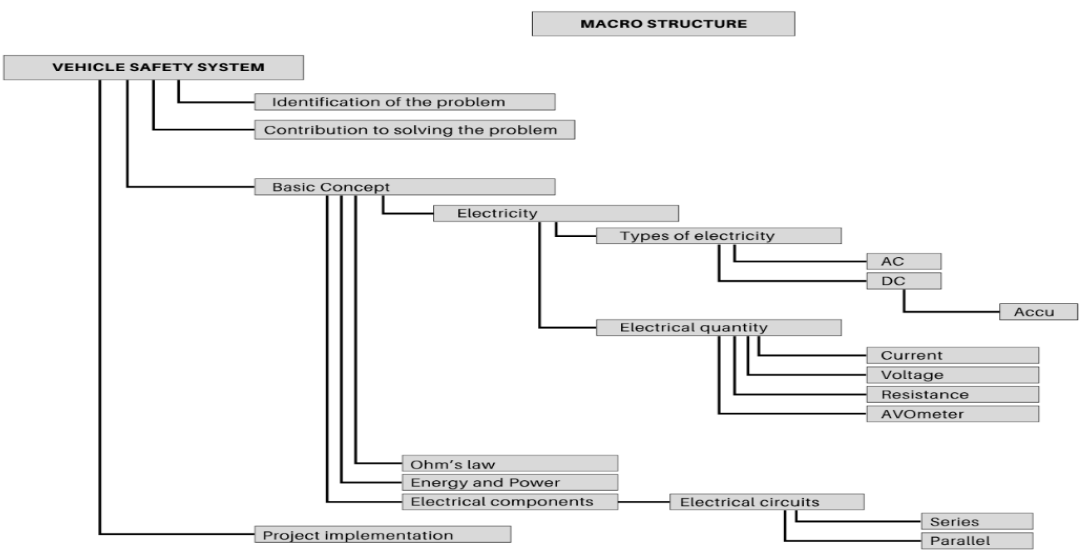


Figure 4. Macrostructure 1

Figure 4 shows the macro structure of the IPAS project module for project 1. The macro structure shows the broad framework of the module content. The arrangement of the macro structure will make it easier for the author to create a sequence of chapters and sub-chapters of a module. As in the figure above, we can see the main chapter of project 1 consists of identifying problems, contributing to finding solutions to problems, learning basic concepts, and finally implementing solutions through a project. The IPAS project module does not only contain concepts or materials but also contains various activities in accordance with the project-based learning model.

The next job in this stage is to compile the materials in the selection stage with the concept map and macro structure as a guide to become a draft module. Some excerpts of the draft IPAS project module are shown in Figure 5.

Figure 5. IPAS project module screenshot

Figure 5 shows an example of a draft of teaching materials resulting from the selection and structuring process. The draft will then be tested for readability and understandability in the characterization stage.

Characterization Stage

The Characterization stage is the stage of analyzing text characters contained in the IPAS project module. Text characters are divided into two categories, namely easy and difficult. The difficult category is further divided into abstract, complex, and complicated.

The characterization of the text is obtained through the results of the readability and comprehension test of the text contained in the module. The following is an example of the results of the summary of the readability and comprehension test of some texts, only 20 texts are presented in the module.

Table 9. Recapitulation of readability and understandability test data

Order	Students' Opinions Regarding the Text		Writing Main Ideas	
	Easy (%)	Difficult (%)	Easy (%)	Difficult (%)
Text 22	83	17	33	67
Text 23	67	33	33	67
Text 25	33	67	17	83
Text 30	17	83	17	83
Text 31	83	17	50	50
Text 32	100	0	17	83
Text 33	83	17	50	50
Text 34	67	33	17	83
Text 35	100	0	50	50
Text 40	100	0	50	50
Text 43	83	17	50	50
Text 47	83	17	50	50
Text 52	83	17	50	50
Text 83	83	17	33	67
Text 91	67	33	50	50

Table 10. Summary of readability and comprehension test data

Text Order	Difficult (%)	Characteristics		
			Difficult	
		Abstract	Complex	Complicated
Text 22	67	√		
Text 23	67	√		
Text 25	83	√		
Text 30	83		√	
Text 31	50		√	
Text 32	83		√	
Text 33	50	√		
Text 34	83		√	
Text 35	50	√		
Text 40	50	√		
Text 43	50		√	
Text 47	50		√	
Text 52	50		√	
Text 83	67		√	
Text 91	50		√	

Based on Table 9, the results of readability and understanding of the science project module, several texts were found to be in the difficult category. There is a difference in the results between students' opinions regarding the ease or difficulty of the text and the results of writing the main idea. Based on students' opinions, the texts that are considered difficult are text no. 25 with a percentage of 67% and text no. 30 with a percentage of 83%. Meanwhile, based on students' ability to write the main idea, the texts that are considered difficult are texts no. 22, 23, and 83 as much as 67%, no. 25, 30, 32, and 34 as much as 83%, no. 31, 33, 35, 40, 43, 47, 52, and 91 as much as 50%. A total of 15 texts out of a total of 97 texts are considered difficult to understand by students.

The results of the readability and understandability tests were then analyzed through text characterization. Difficult texts were categorized into complex, complicated and difficult texts. The characterization of difficult texts is shown in the following Table 10.

Didactic Reduction Stage

Table 11. Didactic reduction of difficult texts

Material/Text Before Reduction	Types of Reduction	Material/Text After Reduction
Analogizing electrical resistance with a crowd of spectators in a football stadium.	Use of analogies and qualitative presentation of text	Analogies are replaced with images and use simpler sentences.
Explanation of current based on images. The explanation is not coherent.	Reformulation of sentences and use of known terms	Explanation of current using simpler sentences.
There are too many formulas for finding the replacement resistance of a parallel circuit.	Abandonment	Using the resistance formula for replacing parallel circuits that has been derived.
The analogy between electrical energy and a waterfall is not very coherent.	Use of analogies and qualitative presentation of text	Analogies for energy are replaced with images and animations and supplemented with simpler sentence explanations.
The explanation of potential difference is quite complicated and should be expressed in simple sentences.	Use of qualitative text presentation	Explanation of potential difference using simpler sentences.
Relay explanation is not coherent.	Reformulation of sentences and use of known terms	Using simpler sentences.
The description of the Arduino pins is not clear, it would be better if it was accompanied by a picture.	Use of images, symbols, animations, videos	Arduino pin explanation complete with pictures.

Material/Text Before Reduction	Types of Reduction	Material/Text After Reduction
Instructions are not clear.	The use of qualitative text presentation	Instructions using simpler sentences.

The last stage in the 4STMD method is the didactic reduction stage. Didactic reduction is an effort to reduce the level of difficulty of teaching materials both qualitatively and quantitatively. Table 11 presents an example of the didactic reduction process in the IPAS project module.

Table 11 shows the didactic reduction process on difficult texts in the science project module using several types of reduction depending on the level of difficulty. After the reduction is complete, all stages of the 4STMD method have been carried out so that the module is ready to be tested for feasibility and implementation in schools.

Final result of the process of developing teaching materials using the 4STMD method in this development research is a module that has met the established criteria, namely in accordance with the demands and scope of the applicable curriculum, the concepts are scientifically correct, integrate both the context of substance and pedagogy, measurable and systematic, each text is estimated to be easy to read and understand.

The initial objective of this development research is to develop a module that can facilitate project-based learning. The IPAS project module with the 4STMD method is very suitable for this purpose, which contains not only content or materials but also steps in project-based learning. In the selection step, activities or activities have been arranged that are in accordance with the stages of project-based learning such as problem orientation, so at the beginning of the module the problem is presented first. In addition, there are instructions that guide students in carrying out activities to find solutions to problems.

This module is also equipped with student worksheets to guide students in working on projects. In general, this IPAS project module contains a series of project-based learning stages by taking a certain theme, while in the development process using the 4STMD method.

Conclusion

This study shows that the science project module developed with the 4STMD approach is suitable for use as teaching materials in project-based learning in vocational schools. The compiled module has met the aspects of readability, understandability, and suitability with learning outcomes, and is able to facilitate contextual, structured learning activities that are oriented towards strengthening applied science literacy. This module has the potential to increase student engagement and support the development of critical thinking and problem-solving skills in a vocational context. However, this study has several limitations. The development process was only carried out up to the validation stage and limited readability test, not yet to the stage of widespread implementation in the actual classroom environment. In addition, the understandability test only involved a small number of respondents, so further testing is needed with a wider and more varied scope to ensure the effectiveness of the module in various contexts and learning conditions. Therefore, further research is recommended to test the impact of the module on learning outcomes, 21st century skills, and real student involvement in the science learning process in vocational schools.

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Conflict of Interest

The authors declare no conflict of interest.

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