JPPIPA 9(12) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

STEAM-Based "IPAS Project" Learning as a Study of the Implementation of the Independent Curriculum in Vocational Schools

Muhammad Syaipul Hayat[1*], Sumarno[2], Mahmud Yunus[3], Noora Qotrun Nada[4]

[1] Master of Science Education Study Program, Postgraduate, Universitas PGRI Semarang, Indonesia
[2] Master of Basic Education, Postgraduate, Universitas PGRI Semarang, Indonesia
[3] Economic Education Study Program, FPIPSKR, Universitas PGRI Semarang, Indonesia
[4] Informatics Study Program, Faculty of Engineering, Universitas PGRI Semarang, Indonesia

Received: October 11, 2023
Revised: November 21, 2023
Accepted: December 25, 2023
Published: December 31, 2023

Corresponding Author:
Muhammad Syaipul Hayat
m.syaipulhayat@upgris.ac.id

DOI: 10.29303/jppipa.v9i12.6005

Abstract: The implementation of the Independent Curriculum in SMK requires science learning to be carried out across disciplines through projects. This study aims to examine the potential and implementation of learning "IPAS project" oriented to the STEAM approach as an implementation of the Merdeka curriculum in SMK. The research was conducted using a survey method with a qualitative descriptive approach involving 48 respondents representing 34 out of 163 vocational schools in Central Java. The instrument used is a questionnaire consisting of three open questions about expectations, obstacles and efforts to overcome them; as well as a five-aspect questionnaire on the profile of teachers' understanding of the application of STEAM-based "IPAS Project" learning in the Merdeka curriculum in SMK. Qualitative descriptive analysis is carried out by data reduction, data display, and conclusion drawing. The results showed that although we have understood aspects of the independent curriculum in learning "IPAS Project", there are still obstacles, especially in the application of the STEAM approach. As for the profile of teachers' understanding of the application of STEAM-based "IPAS project" learning in the Merdeka curriculum in SMK, most teachers already have an understanding of the learning concept of "IPAS project" and in its application have involved many students in the implementation of the Merdeka curriculum. But in understanding the concept of STEAM, most teachers still don't master it well. Likewise, in terms of experience in applying the STEAM approach in "IPAS project", not many teachers have applied it in a structured and systematic manner. Based on this, it is recommended that to reduce the gap in expectations and constraints for vocational teachers, an LMS platform is needed to bridge the implementation of STEAM-based "IPAS Project".

Keywords: Independent curriculum; IPAS project; SMK; STEAM

Introduction

The challenges facing humanity, including those that will be faced by Inonesia's golden generation, are increasingly complex. This has implications for the reconstruction of the national curriculum. Students, especially at the vocational level, need to be prepared to become members of the world community so as to contribute to solving problems related to themselves and the surrounding environment. In addition, they also need to develop their knowledge in the field of natural and social knowledge which is learned in the form of projects so that it can be applied in everyday life (BSKAP, 2022). Thus, SMK graduates in addition to having the ability to meet the demands of the needs and requirements of the world of work, they are also able to develop their potential in adopting and adapting to the development of science, technology, and art through problem solving (Makarim, 2021).

How to Cite:
Hayat, M.S., Sumarno, S., Yunus, M., & Nada, N.Q. (2023). STEAM-Based "IPAS" Learning as a Study of the Implementation of the Independent Curriculum in Vocational Schools. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 12139–12148. https://doi.org/10.29303/jppipa.v9i12.6005

Problems that arise often cannot be solved by looking at it from one point of view, but a holistic and multidisciplinary approach such as natural sciences and social sciences is needed (Hajar & Triastuti, 2021). The implication of this shows that the learning of the "IPAS project" must be carried out in an interdisciplinary or multidisciplinary manner. Interdisciplinary learning encourages students to master various skills so that they are more responsive and continue to exist in the face of changes and developments of the times (Pratiwi et al., 2019).

One of the multidisciplinary learning models can be produced through a combination of PjBL (project-based learning) and STEAM (science, technology, engineering, arts and mathematics) models (Ananda et al., 2022; Rohman et al., 2021; Sigit et al., 2022; Sudjimat et al., 2020; Winarni et al., 2022). STEAM is an integrated approach to encourage creativity (Boy, 2013) critical thinking skills (Ananda et al., 2022), science literacy and attitudes towards the environment (Winarni et al., 2022) STEAM explains that each student involved in it uses various scientific fields which include knowledge, technology, engineering, and mathematics in a real way, which connects schools, the world of work, and the global world (Chung, 2021; Stone, 2022; Winarni et al., 2022). Every part of the STEAM discipline greatly aids student learning in solving problems (Ceylan & Ozdilek, 2015).

Through the STEAM approach, it will be able to improve the quality of engineering education, which includes increasing motivation to learn mathematics and science. Learning with the STEAM approach builds students' cognitive abilities through meaningful learning, raises student creativity and can stimulate the emergence of student soft skills such as cooperation and collaboration in work groups and criticizing surrounding phenomena (Boice et al., 2021; Konkuş & Topsakal, 2022). This strengthens the use of the STEAM approach in the PjBL model together and can improve technical learning outcomes and work character of students in SMK.

The implementation of the PjBL model and the STEAM approach is expected to strengthen the function of IPAS Project subjects in vocational schools, namely equipping students to apply a scientific mindset and good social behavior patterns, be able to make decisions based on natural and social science considerations, find solutions to problems faced through science (Laila et al., 2021). The STEAM approach is proven to be able to integrate several elements of content/material consisting of three elements of scientific literacy that can be contextualized with the characteristics of expertise programs (Muntamah et al., 2023). In addition, the PjBL model and the STEAM approach can integrate natural and social sciences that consider the characteristics of each cluster of expertise, the conditions of the area where they live or schools or local wisdom, as well as the essential content of use from science (Fariziah Choirunisah, 2023; Sakdiah et al., 2022)

The results of the study show that the application of PjBL in learning for vocational students can improve performance, student achievement, learning activities, learning interest and entrepreneurial interest (Anggraini, 2022; Eliza et al., 2019; Mulyadi, 2016; Utama et al., 2020). However, this is not in accordance with the instructional objectives of using the PjBL model, namely improving the ability to solve project problems, acquiring new abilities and skills in learning, and solving complex project problems with real product results (Giang, 2021; Kartini, 2021; Moore, 2021).

On the other hand, the integration of STEAM with the PjBL model has obstacles, such as related to collaboration policies and coordination between subjects and a good STEAM planning process (Shafiul A. et al., 2020; Sudjimat et al., 2020). Research by (Muntamah et al., 2023)found obstacles for teachers of "IPAS Project" subjects in implementing the STEAM approach, such as lack of assistance in applying the STEAM approach to "IPAS Project" learning. Furthermore, other obstacles in implementing PjBL with STEAM are time to carry out STEAM lessons, increased workload, and lack of administrative and financial support (Mardiah et al., 2022; Samsudin et al., 2020; Sigit et al., 2022).

Based on this explanation, the author assumes that through multidisciplinary learning by integrating the STEAM approach in the "IPAS Project" can improve technical learning outcomes and work character of vocational students. The objectives of this study are: first, knowing teachers' perceptions of expectations, obstacles and efforts that have been made in learning "IPAS Project". Second, measuring the profile of teachers' understanding of the application of STEAM-based "IPAS Project" learning in the Merdeka curriculum in SMK.

Method

This research uses a survey method with a qualitative descriptive approach. The survey instrument used consists of two types, namely: three open-ended questions in the form of essays that include expectations, obstacles and efforts to overcome them. In addition, a questionnaire instrument consisting of five aspects is also used. Five aspects of the question are arranged in the form of Likert scale rubrics and require respondents to explain the reasons for the answers they choose. The five aspects measure the profile: the understanding of SMK teachers about the learning concept of "IPAS

project", student involvement in learning "IPAS project", implementation of an independent curriculum, understanding of STEAM concepts, experience applying STEAM in learning "IPAS project".

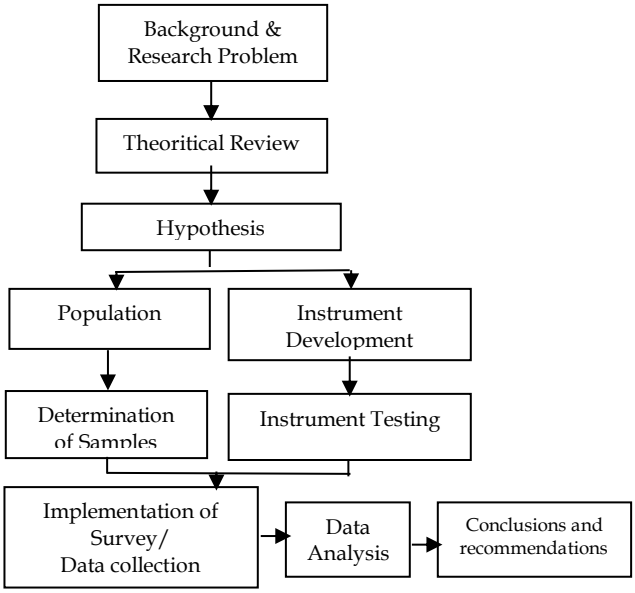

Figure 1. Research flow chart

The population of this study is all teachers of the SMK "IPAS Project" subject in Central Java. The sample of respondents was taken from several population subjects representing teachers of SMK "IPAS Project" subjects in their respective districts / cities in Central Java province. The sampling technique uses multistage purposive sampling. This study involved 48 respondents representing 34 out of 163 vocational schools. Based on the status of SMK studied, the highest number of respondents were private vocational school teachers as much as 64.7% and state vocational teachers as much as 35.3%. Data was collected using google form software which was distributed to all vocational teachers in Central Java. The survey results were analyzed descriptively, so that a description of the level of understanding and implementation of the independent curriculum, understanding of the "IPAS project" and the STEAM approach was obtained. Descriptive analysis is performed with data reduction steps, data display, and conclusions**.**

Result and Discussion

The results of this study consist of two important parts that will be presented. The first is the teacher's perception of the expectations, obstacles and efforts that have been made in teaching the "IPAS Project" in SMK. The second part covers the level of understanding and implementation of the Merdeka curriculum, the "IPAS project" and the STEAM approach along with a description of the quality of the level of understanding and implementation of each of these aspects. More details of the two types of data are presented as follows:

Teachers' perceptions of expectations, obstacles and efforts that have been made in learning "IPAS Project" in SMK

In this first part, data are presented about the answers of teachers to the essay questions given. Questions were given to find out the teacher's response about expectations, obstacles, and efforts that have been made in learning "IPAS Project" by vocational teachers. The summary of the teacher's response is shown in Table 1.

Table 1. Hopes, Obstacles and Efforts of Vocational Teachers in Learning "IPAS Project"

Aspects	Description of the Tendency of Teacher Answers
Expected learning	Create projects that are relevant and can be applied directly by students in their daily lives and provide tangible benefits;
	The "IPAS Project" must be fun, contextual, and beneficial to student life and appropriate to the major;
	Corresponding to real problem solving in the student and teacher environment, both locally and globally;
	Students are active in project activities and can provide experience to apply in everyday life;
	Integrated with other fields to get superior products.
Obstacles that are often encountered	Lack of understanding of the concept of social knowledge in the "IPAS project";
	Designing learning that interest students because students are less responsive and active in learning, including choosing projects and assessments used;
	The budget for the implementation of the project uses considerable funds;
	Less time and learning experience to create an "IPAS project";
	Student learning motivation is lacking, so learning objectives are sometimes not achieved
Efforts to overcome obstacles	Follow technical guidance on designing learning "IPAS Project";
	Discuss with cognate teachers in Preparing lesson plans;
	Design project guidelines independently and fully equipped;
	Choose projects that lack funds and are easy to implement, produce useful and appropriate products,
	Take advantage of existing facilities in the surrounding environment.

Based on the responses of SMK teachers in Table 1, it can be interpreted that in general, teachers have expectations that learning "IPAS Project" can foster students' creative and entrepreneurial spirit through

problem solving and producing useful products. This is in line with the results of research by (Agussuryani et al., 2022) that the learning method of proye-k-based chemistry for secondary metabolite courses of essential oils and terpenes as well as learning tools with an EthnoSTEM approach is effective in improving student conservation and entrepreneurship.

However, they face constraints regarding their own competencies in teaching, infrastructure and financing, and student support. This finding is corroborated by research by (Sudjimat et al., 2020) that teachers are relatively short of time, especially in conducting evaluations because learning focuses more on making products. In addition, teachers also recommend ways to overcome the situation with various alternative solutions, such as: attending "IPAS project" learning design training at SMK, trying to design "IPAS project" learning tools independently and discussing with peers, and orienting projects carried out towards the production of products with high value benefits by the community (Sigit et al., 2022).

Profile of teachers' understanding of the application of STEAM-based "IPAS Project" learning in the Merdeka curriculum at SMK

In the second part, data on the profile of SMK teachers' understanding of the application of STEAM-based "IPAS Project" learning in the Merdeka curriculum is presented. The data includes five aspects measured using questionnaires. In detail the data is presented as follows.

Learning concept "IPAS project"

The first aspect measured is about the learning concept of "IPAS project". This aspect focuses on how teachers' understanding of the learning concept of "IPAS Project" that has been carried out in SMK. The detailed survey data are described in Figure 1.

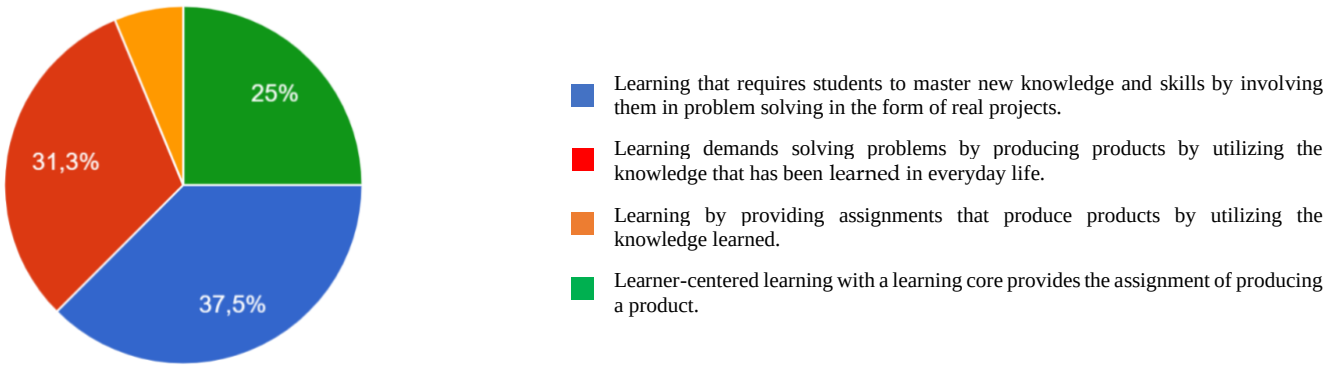

Figure 2. Profile of understanding the learning concept of "IPAS Project" of vocational teachers

Figure 1 shows that 37.5% of teachers understand "IPAS Project" learning, guiding students to master new knowledge and skills by involving them in problem solving in the form of real projects; 31.3% of teachers stated that the learning of "IPAS Project" requires solving problems by producing products by utilizing knowledge that has been learned in everyday life; 25% of teachers respond to learner-centered learning with the core of learning giving the assignment of producing products; and 6.3% of teachers stated learning by giving assignments that produce products by utilizing the knowledge learned.

The data represents that most teachers already have an understanding of the learning concept of "IPAS Project" in SMK. In addition, these results also show that teachers are of the view that implementing a "IPAS Project" must involve students a lot in constructing new knowledge and skills to solve problems through making appropriate products that can be used in everyday life. These findings are in line with the results of research by (Paeßens et al., 2023) that collaboration in VET is effectively used to measure the problem-solving skills of SMK students With a multidimensional authentic technology-based assessment. Likewish (Hanif, 2018) research that student learning outcomes on basic network material increased after participating in project learning at SMK. As well as research by (Muliastawan & Suharsono, 2014) that project learning in SMK can have an influence on increasing mastery of concepts and skills to improve student transmission systems. This is a very good capital in the implementation of "IPAS Project" learning, because most teachers have understood the concept of projects that must be applied in SMK.

Student involvement in learning "IPAS project"

The second aspect is the sustainability of the first aspect which asks the teacher's experience in implementing the learning "IPAS Project". The focus of this aspect is to ask about student involvement in learning "IPAS Project" that have been carried out by teachers in SMK. The survey results that have been collected are illustrated in Figure 2.

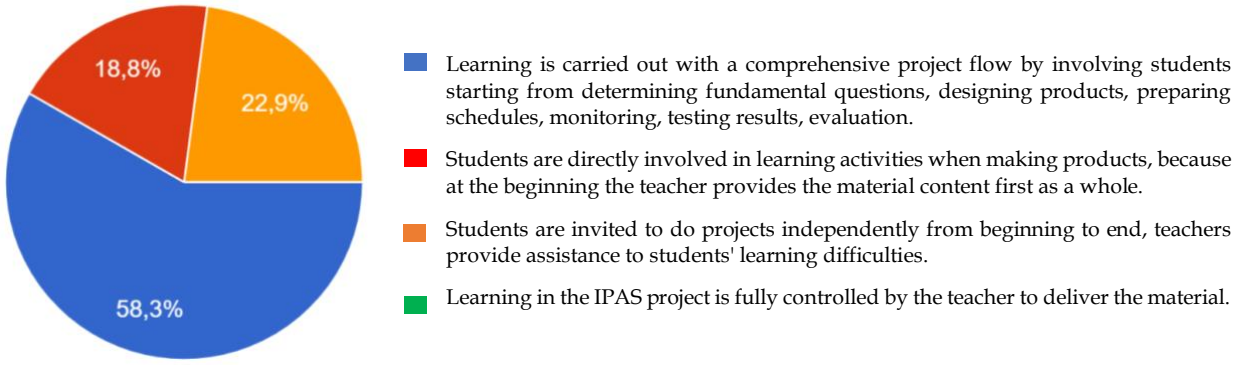

Figure 3. Student involvement in learning "IPAS Project" in SMK

Based on Figure 2, as many as 58.3% of teachers have involved students in project activities comprehensively ranging from determining basic questions, designing products, preparing schedules, monitoring, testing results, evaluation; 22.9% of students are invited to do projects independently from start to finish, teachers provide assistance to students' learning difficulties; 18.8% of students are directly involved in learning activities when making products, because at the beginning the teacher provides the material content first as a whole; and 0% who stated that learning in the "IPAS Project" was controlled entirely by the teacher to deliver the material.

The data can be interpreted that most teachers have involved students in project activities, but the implementation varies, some are guided thoroughly in each phase of project activities based on PjBL syntax, some ask students to make projects independently, and some even directly ask students to make products assuming that the material has been given by the teacher. From all survey results, none of the respondents stated that project learning was fully controlled by teachers in its implementation. That is, this has become a positive response that in the field in the application of project learning, students have been involved a lot, just optimizing the involvement to be more structured. This data is corroborated by (Becerra-Posada et al., 2022) research that project learning can promote students' communication skills and self-confidence in Colombia. Likewise, Wuxue's research (2023) confirms that project learning through blended learning has an effective influence on improving student learning outcomes. In addition, there is a need for scaffolding at every stage of the project, so that the objectives of project activities are right on target as planned (Yanti et al., 2023) Research by (Tikva & Tambouris, 2023) scaffolding conducted on programming games can improve the development of computational thinking. (Chang & Yang, 2023) research explains that scaffolding in game-based digital learning and cognitive styles on students' emotions exert an interactive influence on cognitive load and performance in learning.

Implementation of the Independent Curriculum

This third aspect asks about teachers' understanding in the implementation of the Merdeka curriculum in SMK. The main focus of the survey on this aspect is how to implement the project in the Merdeka curriculum. The detailed surver data is presented in Figure 3.

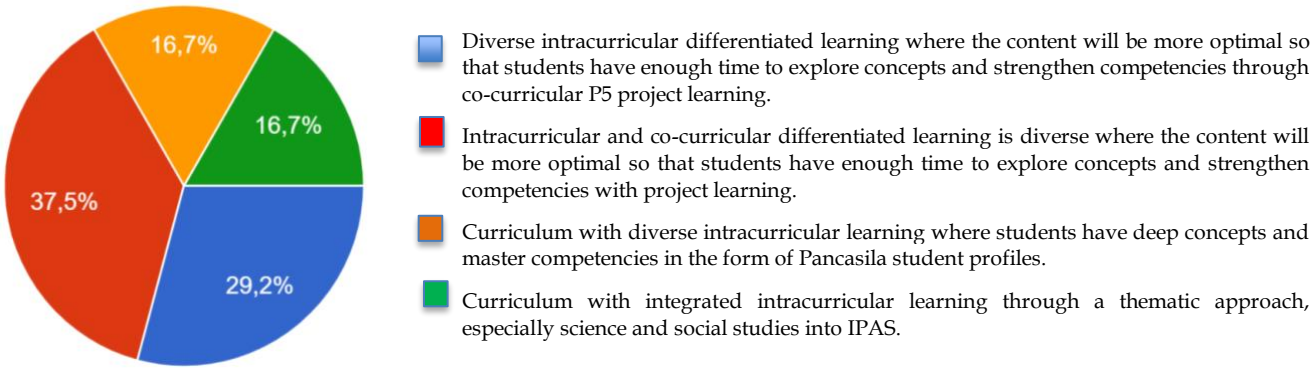

Figure 3. Teacher profile on the implementation of the independent curriculum in SMK

Figure 3 shows data that 37.5% in implementing the Merdeka curriculum need to apply diverse intracurricular and co-curricular differentiated learning where the content will be more optimal so that students have enough time to explore concepts and strengthen competencies with project learning; 29.2% stated that intracurricular differentiated learning is diverse where the content will be more optimal so that students have enough time to explore concepts and strengthen competencies through co-curricular learning of P5 projects; 16.7% curriculum with diverse intracurricular learning where students have deep concepts and master competencies in the form of Pancasila student profiles; and 16.7% of the curriculum with integrated intracurricular learning through thematic approaches, especially science and social studies became IPAS.

The data in Figure 3 interprets that most teachers have implemented project learning according to the mandate of the Merdeka curriculum, especially by implementing differentiated learning which is expected so that students can carry out "IPAS project" activities according to their respective learning profiles. However, there are still quite a lot of people who have not implemented project learning in the Merdeka curriculum as a whole. Therefore, there is a need for a learning formulation model for "IPAS Project" that is applied comprehensively with full student involvement based on their respective learning profiles.

Understanding of STEAM concepts

Understanding the STEAM concept is an aspect that underlies the experience of vocational teachers applying the STEAM approach in learning "IPAS Project". This aspect is more focused on the understanding of vocational teachers towards the STEAM concept that they have mastered. The data from the survey on understanding the STEAM concept for vocational teachers are explained in Figure 4.

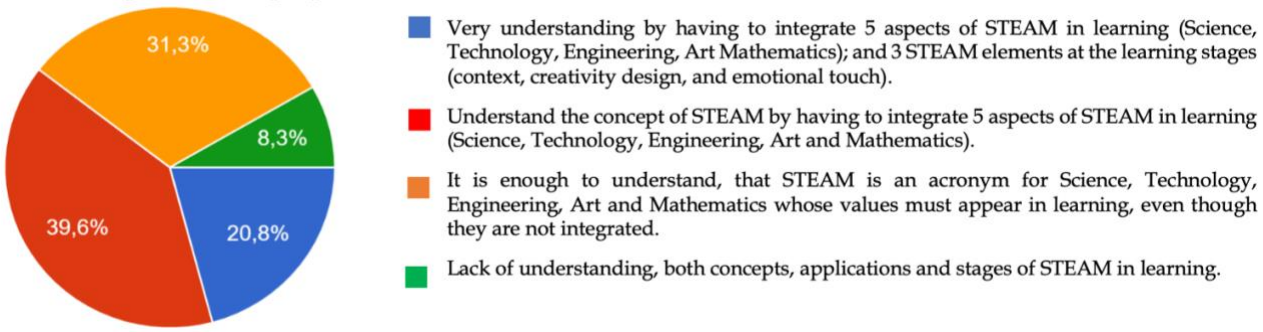

Figure 4. Teacher's understanding of STEAM concepts

The data in Figure 4 shows that as many as 39.6% of teachers have understood the STEAM concept by having to integrate 5 aspects of learning (Science, Technology, Engineering, Art and Mathematics). As many as 31.3% of teachers understand that STEAM is an acronym for Science, Technology, Engineering, Art and Mathematics whose values must appear in learning, even though they are not integrated. In addition, 20.8% are very familiar with having to integrate 5 aspects of STEAM in learning (Science, Technology, Engineering, Art Mathematics); and 3 STEAM elements at the learning stages (context, creativity design, and emotional touch), and 8.3% lack understanding, both concepts, applications and stages of STEAM in learning.

The survey results for this aspect interpret that there are still many teachers who do not fully understand the STEAM concept that can be integrated in learning "IPAS Project". Especially in integrating components (Science, Technology, Engineering, Art Mathematics) and STEAM elements (context, creativity design, and emotional touch) in learning. This is because it is not uncommon for vocational teachers to apply the STEAM approach in learning "IPAS Project". In fact, when viewed from its characteristics, learning "IPAS Project" has a very high relevance to the principles of the STEAM approach (Qomaria & Wulandari, 2022; Toto et al., 2022). Both actively involve students in a series of project activities and produce products as outputs of learning (Agussuryani et al., 2022; Hajar & Triastuti, 2021; Noto Widodo, Pardjono, 2013).

Experience applying STEAM in science learning

The fifth aspect focuses on teachers' experience of applying STEAM in learning "IPAS Project" in vocational schools. In this aspect, we want to measure how teachers are accustomed to learning science through projects with the help and approach of STEAM after they understand the concept. Therefore, STEAM is one of the relevant approaches to accommodate vocational learning. Students can be directly involved in every stage of the project, because through STEAM students are naturally guided more intensively. Survey data on teachers' experiences in learning "IPAS Project" through the STEAM approach are described in Figure 5.

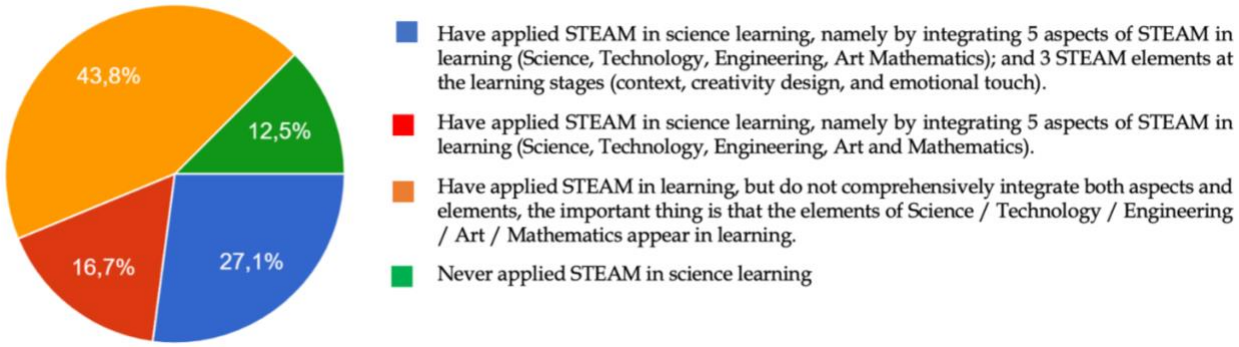

Figure 5. Teacher experience applying STEAM in science learning in SMK

Based on Figure 5, as many as 43.8% of teachers have applied STEAM in science learning, but do not comprehensively integrate both aspects and elements, the important thing is that the elements of Science / Technology / Engineering / Art / Mathematics appear in learning. 27.1% have applied STEAM in science learning, namely by integrating 5 aspects of STEAM in learning (Science, Technology, Engineering, Art Mathematics); and 3 STEAM elements at the learning stages (context, creativity design, and emotional touch). 16.7% have applied STEAM in science learning, namely by integrating 5 aspects of STEAM in learning (Science, Technology, Engineering, Art and Mathematics), while 12.5% have never applied STEAM in science learning.

The data interprets that most teachers have not applied the principles of the STEAM approach in a structured and comprehensive manner in learning "IPAS Project", but have only attached STEAM components to several steps of learning activities. This requires more comprehensive planning so that the application of the STEAM approach in learning "IPAS Project" is more systematic, both the application of components (Science, Technology, Engineering, Art Mathematics) and the three main elements of STEAM (contect, design creativity, and emotional touch) (Kartika et al., 2021; Wittayakhom & Piriyasurawong, 2020). In addition, (Nuraini et al., 2023)in their research explained that the integration of STEAM in project learning can improve learning outcomes and science literacy. (Subiki et al., 2023)stated that the integration of the STEAM approach in project learning has an effect on improving student learning outcomes in material elasticity. The application of the STEAM learning approach can also improve the science process skills and scientific attitudes of vocational students (Sakdiah et al., 2022).

Conclusion

In general, SMK teachers have the hope that learning "IPAS Project" can foster students' creative and entrepreneurial spirit through problem solving and producing useful products. However, they face constraints regarding their own competencies in teaching, infrastructure and financing, and student support. In addition, teachers also recommend how to overcome the situation with various alternative solutions, such as: attending learning design training "IPAS project", trying to design learning tools "IPAS project" independently and discussing with colleagues, and orienting projects carried out towards the production of products with high value benefits by the community. As for the profile of teachers' understanding of the application of STEAM-based "IPAS project" learning in the Merdeka curriculum in SMK, most teachers already have an understanding of the concept of learning the IPAS project in SMK and in its application have involved many students in the implementation of the Merdeka curriculum. But in understanding the concept of STEAM, most teachers still don't master it well. Likewise, in terms of experience in applying the STEAM approach in "IPAS Project", not many teachers have applied it in a structured and systematic manner. Based on this, it is recommended that to reduce the gap in expectations and constraints for vocational teachers, an LMS platform is needed to bridge the implementation of STEAM-based "IPAS Project", so that they can be more systematic, structured and effective.

Acknowledgments

We would like to express our gratitude to the Ministry of Education and Culture, Research and Technology for the funding support in the 2023 DRTPM research grant received by the team

Author Contributions

All members of the research team contributed to the writing of this article. "Conceptualization of ideas, Muhammad Syaipul Hayat; literature, Mahmud Yunus; methodology and instruments, Sumarno; analysis and presentation of data, Noora Qotrun Nada".

Funding

This research was funded by the Ministry of Education and Culture, Research and Technology in the DRTPM Regular

Fundamental Research scheme (first year) research grant program.

Conflicts of Interest
The authors declare no conflict of interest.

References

Agussuryani, Q., Sudarmin, S., Sumarni, W., Cahyono, E., & Ellianawati, E. (2022). STEM literacy in growing vocational school student HOTS in science learning: A meta-analysis. *International Journal of Evaluation and Research in Education*, *11*(1), 51–60. https://doi.org/10.11591/ijere.v11i1.21647

Ananda, L. R., Rahmawati, Y., & Khairi, F. (2022). Critical Thinking Skills of Chemistry Students By Integrating Design Thinking With Steam-Pjbl. *Journal of Technology and Science Education*, *13*(1), 352–367. https://doi.org/10.3926/jotse.1938

Anggraini, N. A. (2022). *Pengaruh Pemotongan Akar Tanaman Air terhadap Penurunan BOD dan COD Limbah Domestik dengan Metode Fitoremediasi*. *3*(1), 65–74. Retrieved from https://esec.upnvjt.com/index.php/prosiding/article/view/123

Becerra-Posada, T., García-Montes, P., Sagre-Barbosa, A., Carcamo-Espitia, M. I., & Herazo-Rivera, J. D. (2022). Project-based Learning: The Promotion of Communicative Competence and Self-confidence at a State High School in Colombia. *How*, *29*(2), 13–31. https://doi.org/10.19183/how.29.2.560

Boice, K. L., Jackson, J. R., Alemdar, M., Rao, A. E., Grossman, S., & Usselman, M. (2021). Supporting teachers on their STEAM journey: A collaborative STEAM teacher training program. *Education Sciences*, *11*(3), 1–20. https://doi.org/10.3390/educsci11030105

Boy, G. A. (2013). From STEM to STEAM: Toward a Human-Centered Education. *European Conference on Cognitive Ergonomics*, 8p. https://doi.org/10.1145/2501907.2501934

BSKAP. (2022). *Badan Standar, Kurikulum, Dan Asesmen Pendidikan Kementerian Pendidikan, Kebudayaan, Riset, Dan Teknologi Tentang Capaian Pembelajaran Mata Pelajaran Ilmu Pengetahuan Alam dan Sosial (IPAS)* (pp. 1–59). Retrieved from https://kurikulum.kemdikbud.go.id/file/cp/dasmen/13.%20CP%20IPAS.pdf

Ceylan, S., & Ozdilek, Z. (2015). Improving a Sample Lesson Plan for Secondary Science Courses within the STEM Education. *Procedia - Social and Behavioral Sciences*, *177*(July 2014), 223–228. https://doi.org/10.1016/j.sbspro.2015.02.395

Chang, C. C., & Yang, S. T. (2023). Interactive effects of scaffolding digital game-based learning and cognitive style on adult learners' emotion, cognitive load and learning performance. *International Journal of Educational Technology in Higher Education*, *20*(1). https://doi.org/10.1186/s41239-023-00385-7

Chung, S. K. (2021). *Issues-Based STEAM Education: A Case Study in a Hong Kong Secondary School*. https://doi.org/10.26209/ijea22n3

Eliza, F., Suriyadi, S., & Yanto, D. T. P. (2019). Peningkatan Kompetensi Psikomotor Siswa Melalui Model Pembelajaran Project Based Learning (PjBL) di SMKN 5 Padang. *INVOTEK: Jurnal Inovasi Vokasional Dan Teknologi*, *19*(2), 57–66. https://doi.org/10.24036/invotek.v19i2.427

Fariziah Choirunisah. (2023). *Evaluasi Pelaksanaan Pjbl Berbasis Steam Dalam Pembelajaran Ekonomi SmA*. *1*(July), 1–23. Retrieverd from https://jurnal.widyahumaniora.org/index.php/jptwh/article/view/166

Giang, N. N. (2021). Project-Based Learning on the Topic of Aromatic Wax Production. *Journal of Education and E-Learning Research*, *8*(4), 395–407. https://doi.org/10.20448/JOURNAL.509.2021.84.395.407

Hajar, I., & Triastuti, A. (2021). A Need Analysis of ESP materials for Agriculture Students at Indonesian Vocational School in West Sulawesi. *IJELTAL (Indonesian Journal of English Language Teaching and Applied Linguistics)*, *6*(1), 13. https://doi.org/10.21093/ijeltal.v6i1.840

Hanif, F. M. (2018). Meningkatkan Hasil Belajar Jaringan Dasar Model Pembelajaran Berbasis Proyek (Project Based Learning) Siswa Kelas X Tkj 1 Smkn 1 Bangkinang Fajri M . Hanif seorang guru untuk mengembangkan kemampuan dan keterampilannya . Guru jangan berpuas diri ketika. *Jurnal Pendidikan Tambusai*, *2*(1), 1–13. https://doi.org/10.31004/jptam.v2i1.53

Kartika, E. F. R., Elfi, S. V., & Indriyanti, N. Y. (2021). Development and Validation of Web-Based Steam Online Platform To Improve Learning Quality in Pre-Service Chemistry Teachers. *Journal of Technology and Science Education*, *11*(2), 513–525. https://doi.org/10.3926/JOTSE.1316

Kartini, F. S. (2021). Promoting Student's Problem-Solving Skills through STEM Project-Based Learning in Earth Layer and Disasters Topic. *Journal of Science Learning*, *4*(3), 257–266. https://doi.org/10.17509/jsl.v4i3.27555

Konkuş, Ö. C., & Topsakal, Ü. U. (2022). The Effects of STEAM-Based Activities Gifted Students' STEAM Attitudes, Cooperative Working Skills and Career Choices. *Journal of Science Learning*, *5*(3). https://doi.org/10.17509/jsl.v5i3.46215

Laila, N., Rusydiana, A. S., Irfany, M. I., Imron, H. R.,

Srisusilawati, P., & Taqi, M. (2021). Energy economics in Islamic countries: A bibliometric review. *International Journal of Energy Economics and Policy*, *11*(2), 88–95. https://doi.org/10.32479/ijeep.10763

Makarim, N. (2021). *Keputusan Menteri Pendidikan, Kebudayaan, Riset, Dan Teknologi Republik Indonesia tentang SMK Pusat Keunggulan* (p. 1). Retrieved from https://jdih.kemdikbud.go.id/sjdih/siperpu/dokumen/salinan/salinan_20220215_093900_Salinan%20Kepmendikbudristek%20No.56%20ttg%20Pedoman%20Penerapan%20Kurikulum.pdf

Mardiah, A., Rahmawati, Y., Harun, F. K. C., & Hadiana, D. (2022). Transferable skills for pre-service chemistry teachers in Indonesia: Applying a design thinking-STEAM-PjBL model. *Issues in Educational Research*, *32*(4), 1509–1529. Retrieved from https://www.researchgate.net/publication/366323543_Transferable_skills_for_pre-service_chemistry_teachers_in_Indonesia_Applying_a_design_thinking-STEAM-PjBL_model

Moore, S. W. (2021). Adopting a Project-Based Learning Framework in an Online Course to Enhance the Quality of Student Projects. *International Society for Technology, Education, and Science*, 144–149. Retrieved from https://eric.ed.gov/?id=ED626274

Muliastawan, I. K., & Suharsono, N. (2014). Pengaruh Model Pembelajaran Berbasis Proyek terhadap Pemahaman Konsep dan Keterampilan Memperbaiki Sistem Transmisi di SMK. *E-Journal Program Pascasarjana Universitas Pendidikan Ganesha*, *4*(11), 1–13. https://doi.org/10.23887/jtpi.v5i1.1090

Mulyadi, E. (2016). Penerapan Model Project Based Learning untuk Meningkatan Kinerja dan Prestasi Belajar Fisika Siswa SMK. *Jurnal Pendidikan Teknologi Dan Kejuruan*, *22*(4), 385. https://doi.org/10.21831/jptk.v22i4.7836

Muntamah, M., Roshayanti, F., & Hayat, M. S. (2023). Potensi Penerapan Pendekatan STEAM (Science, Technology, Engineering, Art, Mathematics) pada Pembelajaran Projek IPAS (Ilmu Pengetahuan Alam dan Sosial) di SMK. *Jurnal Inovasi Pembelajaran Di Sekolah*, *4*(1), 77–83. https://doi.org/10.51874/jips.v4i1.79

Noto Widodo, Pardjono, W. (2013). Pengembangan Model Pembelajaran Soft Skills Dan Hard Skills Untuk Siswa Smk. *Jurnal Cakrawala Pendidikan*, *3*, 409–423. https://doi.org/10.21831/cp.v0i3.1139

Nuraini, N., Asri, I. H., & Fajri, N. (2023). Development of Project Based Learning with STEAM Approach Model Integrated Science Literacy in Improving Student Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 1632–1640. https://doi.org/10.29303/jppipa.v9i4.2987

Paeßens, J., Ma, B., & Winther, E. (2023). Effectiveness of Collaboration in VET: Measuring Skills for Solving Complex Vocational Problems With a Multidimensional Authentic Technology-Based Assessment. *International Journal for Research in Vocational Education and Training*, *10*(1), 46–67. https://doi.org/10.13152/IJRVET.10.1.3

Pratiwi, S. N., Cari, C., Aminah, N. S., & Affandy, H. (2019). Problem-Based Learning with Argumentation Skills to Improve Students' Concept Understanding. *Journal of Physics: Conference Series*, *1155*(1). https://doi.org/10.1088/1742-6596/1155/1/012065

Qomaria, N., & Wulandari, A. Y. R. (2022). Pengembangan Keterampilan Kolaboratif Siswa Melalui Pembelajaran Dengan Pendekatan Ethno-Steam Project Konteks Pesapean. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *11*(2), 1306. https://doi.org/10.24127/ajpm.v11i2.4586

Rohman, M. H., & Marwoto, P. (n.d.). *The Needs Analysis for the Development of an Ethnoecological-STEAM Project-Based Learning Model with the Utilization of Water Hyacinth to Improve 21st Century*. International. Retrieved from https://proceeding.unnes.ac.id/index.php/ISET/article/view/2455

Sakdiah, H., Ginting, F. W., Rejeki, N. S., & Miranda, A. (2022). Pembelajaran STEAM Terhadap Keterampilan Proses Sains Ditinjau dari Sikap Ilmiah Mahasiswa pada Mata Kuliah Kajian Fisika Kejuruan. *Jurnal Penelitian Pendidikan IPA*, *8*(5), 2531–2536. https://doi.org/10.29303/jppipa.v8i5.2313

Samsudin, M. A., Jamali, S. M., Zain, A. N. M., & Ebrahim, N. A. (2020). The effect of STEM project based learning on self-efficacy among high-school physics students. *Journal of Turkish Science Education*, *17*(1), 94–108. https://doi.org/10.36681/tused.2020.15

Shafiul A., M., Agus S., D., & Nurhadi, D. (2020). Mengkombinasikan Project-Based Learning dengan STEM untuk Meningkatkan Hasil Belajar Teknikal dan Karakter Kerja Siswa SMK. *Februari*, *43*(1), 41–50. https://doi.org/10.17977/um031v43i12020p41-50

Sigit, D. V., Ristanto, R. H., & Mufida, S. N. (2022). Integration of Project-Based E-Learning with STEAM: An Innovative Solution to Learn Ecological Concept. *International Journal of Instruction*, *15*(3), 23–40. https://doi.org/10.29333/iji.2022.1532a

Stone, B. (2022). Holistic Identity Development in

STEAM. *International Journal of the Whole Child*, *7*(1), 75–83. Retrieved from https://eric.ed.gov/?id=EJ1347541

Subiki, S., Elika, E. T. P., & Anggraeni, F. K. A. (2023). Effect of the Project-Based Learning Model with the STEAM Approach on Learning Outcomes of High School Students the Subject of Material Elasticity. *Jurnal Penelitian Pendidikan IPA*, *9*(2), 745–751. https://doi.org/10.29303/jppipa.v9i2.2926

Sudjimat, D. A., Nyoto, A., & Romlie, M. (2020). Implementation of Project-Based Learning Model and Workforce Character Development for the 21st Century in Vocational High School. *International Journal of Instruction*, *14*(1), 181–198. https://doi.org/10.29333/IJI.2021.14111A

Tikva, C., & Tambouris, E. (2023). The effect of scaffolding programming games and attitudes towards programming on the development of Computational Thinking. *Education and Information Technologies*, *28*(6), 6845–6867. https://doi.org/10.1007/s10639-022-11465-y

Toto, Fatimah, A. T., & Isyanto, A. Y. (2022). Identifikasi Konsep-Konsep Fisika dalam Pembelajaran Berbasis STEAM-H di SMK Agribisnis. *Prosiding Seminar Nasional Fisika*, *1*, 20–30. Retrieved from http://proceedings2.upi.edu/index.php/sinafi/article/view/2976

Utama, A., Jalinus, N., Jasman, J., & Hasanuddin, H. (2020). Implementasi Pembelajaran Project Based Learning Untuk Meningkatkan Aktifitas Dan Hasil Belajar Produk Kreativitas Kewirausahaan Siswa Kelas Xi Smk Negeri 1 Bukittinggi. *Jurnal Vokasi Mekanika (VoMek)*, *2*(2), 48–55. https://doi.org/10.24036/vomek.v2i2.96

Winarni, E. W., KARPUDEWAN, M., KARYADI, B., & GUMONO, G. (2022). Integrated PjBL-STEM in Scientific Literacy and Environment Attitude for Elementary School. *Asian Journal of Education and Training*, *8*(2), 43–50. https://doi.org/10.20448/edu.v8i2.3873

Wittayakhom, N., & Piriyasurawong, P. (2020). Learning Management STEAM Model on Massive Open Online Courses Using Augmented Reality to Enhance Creativity and Innovation. *Higher Education Studies*, *10*(4), 44. https://doi.org/10.5539/hes.v10n4p44

Wuxue, J. (2023). The Influence of Optimized Blended Learning Mode on Learning Effectiveness for Higher Vocational College Students: A Quasi-Experimental Study in Higher Vocational College. *TOJET : The Turkish Online Journal of Educational Technology*, *22*(2), 121–130. Retrieved from http://www.tojet.net/volumes/v22i2.pdf#page=131

Yanti, N. L. I. M., Redhana, W., & Suastra, W. (2023). Multiple Scaffolding STEAM Project-Based Learning Model In Science Learning. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 6493–6502. https://doi.org/10.29303/jppipa.v9i8.4470