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Exploration of integrated mathematics learning with teaching factory learning for vocational high school pharmacy students based on design thinking

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Abstract

There are still many vocational high school students who struggle with mathematics and need mathematics instruction that is more focused on what they need to support their vocational studies. This study aims to qualitatively and quantitatively explore emerging issues in mathematics learning using the design thinking method, which consists of 5 stages: empathize, define, ideate, prototype, and test. In this research exploration, only the first 3 stages were completed: empathize, define and ideate. The study population consisted of 10th-grade students majoring in pharmacy and mathematics teachers at SMK Al Manaar Muhammadiyah, SMK Amanah Husada, and SMK Media Farma, with 50 10th-grade student respondents and 6 teachers. Quantitative data were collected via a Google Forms questionnaire, while qualitative data were collected through interviews. The data were then analyzed from the empathy stage to the ideate stage, and it was found that students and teachers in mathematics learning need direct practice to support their vocational skills. Therefore, the researcher concludes that it is necessary to integrate mathematics learning into the vocational studies of SMK students, which can involve the active participation of both students and teachers in mathematics learning.

Keywords: design thinking; integrated mathematics learning; teaching factory

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I. Introduction

In the current era of Industry 4.0, the increasing competition in the business and industry world requires Vocational High Schools (SMK) to possess significant capabilities and potential to play a role in reducing the unemployment rate (Morley, 2024). In addition, it produces human resources (HR) who are not only skilled in their competencies but also problem solvers in various fields and other important areas. In vocational high schools (SMK), students choose specific majors and learn specialized skills within them, so it is expected that SMK graduates will be ready to work in their respective fields. This is a significant challenge that the Indonesian government must face in an effort to create a competent workforce in accordance with the competencies needed in the world of work,

namely the business/industrial world (Disas, 2018). One of the competencies that needs to be considered is problem-solving skills, which include the ability, proficiency, and capability of students to draw conclusions or express opinions or statements (Putri, 2023; Zaenab, 2015).

Based on the content standards set forth in Permendikbud No. 21 of 2016, mathematics in vocational schools consists of materials with a scope almost identical to that of the mandatory mathematics in high schools. The scope of these materials is the minimum standard that can be further developed to suit students' abilities and majors. One important consideration for why mathematics is studied in vocational schools (SMK) is that students have a mathematical understanding to support the execution of tasks in line with their expertise (Regulation of the Minister of Education and Culture of the Republic of Indonesia Number 34 of 2018).

The results of the questionnaire and interviews conducted with 10th-grade Pharmacy students at three vocational schools in Pemalang that have a pharmacy program, namely SMK Al Manaar Muhammadiyah, SMK Amanah Husada, and SMK Medika Farma, revealed that many students still consider mathematics lessons to be quite enjoyable and difficult to learn, making it easy to forget during practice. The mathematics learning process in class often makes them feel bored, leading to passive learning activities. Many of them admitted to preferring other subjects that are often conducted outside the classroom, such as laboratory practicals. This is in line (Kristanto & Hery (2019) who stated that student boredom in the learning process causes students to appear bored during mathematics lessons, thereby reducing their motivation to learn.

From the journal study conducted, namely the research by (Fatimah & Solihah, 2021), it is stated that the role of mathematics can be integrated into mathematics learning by utilizing contexts from vocational fields to construct mathematical concepts or present mathematical task/problem situations. Contextual knowledge in vocational education can be used to develop mathematical understanding that aligns with students' expertise competencies (Mahmuti, Hamzic, & Thaqi, 2025; Xueting & Ismail, 2024). Then, in the research by Agustin & Santosa (2022) this indicates a positive contribution to improved mathematics learning outcomes in their field.

Based on the problems described above, the researcher is interested in identifying several solutions to encourage students to discover concepts/procedures on their own in mathematics lessons that align with industry standards, thereby enhancing the development of knowledge, processes, and attitudes, namely by integrating factory learning into mathematics lessons. Previous research on teaching factory learning has not yet discussed in detail the integration of mathematics lessons into the teaching factory learning model. Some of them are still generally related to the teaching factory learning model, including Ahmad, Setyowati, & Nusantari (2023) who state that teaching factory learning is a solution for producing learning outcomes through various learning process strategies. Moreover, in Perdana, (2018) research, it was stated that the teaching factory learning model increases students' motivation to participate in learning activities and positively impacts students' evaluation results. In research in another field by Pahmi, Hudaya, & Jaya (2023) was stated that the teaching factory learning model in physics subjects resulted in better student learning outcomes compared to conventional learning, with aspects of thinking skills such as fluency, flexibility, originality, elaboration, and curiosity falling into the very good category, and aspects of discipline, responsibility, and honesty falling into the good category. Based on the researcher's above journal analysis, no specific discussion was found regarding the in-depth reasons for students' needs in mathematics learning that could be implemented directly in the field, especially for students' vocational skills.

In the explanation above, in this study, the researcher is interested in exploring Integrated Mathematics Learning with Teaching Factory for

SMK Pharmacy students, using the design thinking method. This method refers to the Stanford Design School framework with five phases: Empathize, Define, Ideate, Prototype, and Test/Evaluate. In this study, the exploration phase only reached the ideation stage.

II. Research Method

This type of research is descriptive qualitative with the design thinking method because this method has advantages in finding solutions to a problem and can solve problems by creating ideas (products, services, systems) in complex issues, and can offer a new approach for a specific group of people (Lindberg, Noweski, & Meinel, 2010). Design thinking is described as a way of thinking or a cognitive process that manifests in the act of designing a thot process (Dunne & Martin, 2006). Design thinking offers concrete solutions to solve complex, well-defined, and not easily understood problems, and here are the stages or phases of the Stanford School of Design Thinking (Schmarzo, 2017):

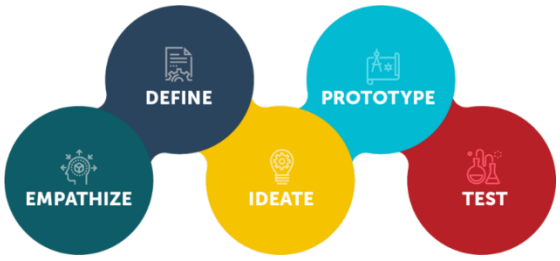

Figure 1. Design thinking

The research was conducted at SMK Al Manaar Muhammadiyah, SMK Amanah Husada, and SMK Media Farma in February 2025, where the population in this study consisted of 10th-grade students and mathematics teachers who teach at these schools with the independent curriculum. Then, the sample of research subjects consisted of 50 students from the 10th grade Pharmacy major and 6 math teachers for the 2024/2025 academic year. The research subjects were selected using purposive sampling, which is a data sampling method based on specific criteria. Specifically, 50 students were randomly selected from the same major, pharmacy, who experienced similar difficulties in the mathematics learning process, as stated by 6 mathematics teachers, namely, passive learning.

III. Results and Discussion

The Empathize Stage

The empathize stage, which involves approaching users to gather information and understand their needs through observation and interviews (Cantika & Susetyo, 2023). Understanding is empathetically formed through asking questions and listening, exploring user experiences, and making user needs the primary goal of the design (Lindberg et al., 2010)

At this stage, the researcher begins by collecting the amount of data to be sampled, then the information from that data is explored in depth to obtain in-depth information using questionnaires and interviews containing several questions that will be used for initial data collection.

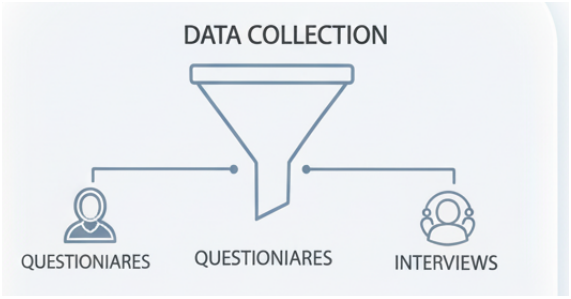

Figure 2. Data collection analysis

And here is the sample size for this study:

Table 1. Number of student respondents

School	Participants	Percentage
SMK Al Manaar Muhammadiyah	20	40
SMK Amanah Husada	14	28
SMK Medika Farma	16	32
Jumlah	50	100

From the student respondents above, it can be determined that the sample size from the 3 schools consists of 50 students, with details as

follows: SMK Al Manaar Muhammadiyah with 20 students (40%), SMK Amanah Husada with 14 students (28%), and SMK Media Farma with 16 students (32%).

Table 2. Number of teacher respondents

School	Participants	Percentage
SMK Al Manaar Muhammadiyah	2	33,33
SMK Amanah Husada	2	33,33
SMK Medika Farma	2	33,33
Jumlah	6	100

From the above teacher respondents, it can be determined that the sample size from 3 schools consists of 6 teachers, with 2 teachers from each school, each representing 33.33%.

After data collection, the next step is to delve deeper into the information through questionnaires and interviews with 50 respondents from the three schools and 6 teachers. The results of the interviews and questionnaires are then compiled into an empathy map, which helps researchers understand user needs and serves as a consideration in decision-making (Rapri, Rokhmawati, & Hanggara, 2022). The empathy map is divided into four quadrants: saying, thinking, feeling, and doing.

Here are the results of the student empathy map and teacher empathy map based on the analysis of questionnaires and interviews.

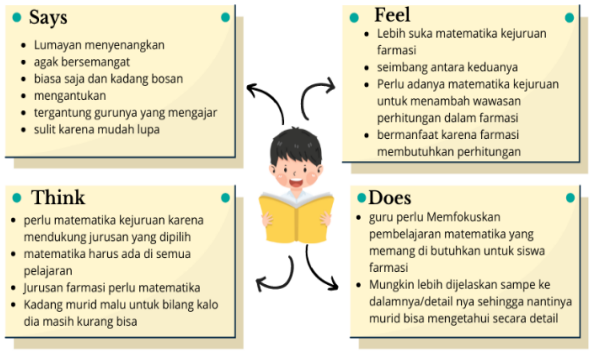

Figure 3. Empathy map of the students

In the empathy map of the students above, the researcher found several things that can be analyzed, including that students consider mathematics lessons to be quite enjoyable and challenging to learn, making it easy to forget during problem-solving. In their findings, Utomo, Muhtarom, & Dwijayanti (2024) stated that many students still consider mathematics a difficult subject, with weak conceptual understanding and difficulty with problem-solving. In that research, the researcher can explore in more depth the reasons why students have difficulty solving problems. According to (Nurbayeni, 2024), students who experience learning difficulties in mathematics do not achieve optimal learning outcomes. Then, during the learning process, students need a mathematics education that focuses on what they need, specifically for the pharmacy major, to support their abilities in pharmaceutical calculations.

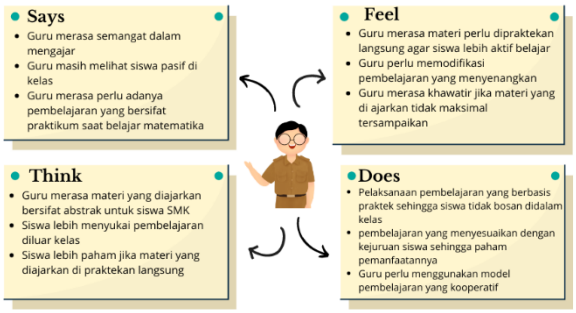

Figure 4. Empathy map of the teacher

Then, on the teacher's empathy map above, the researcher found several things that can be analyzed, including in the mathematics learning process, the teacher found that students prefer learning conducted outside the classroom and appear more active when the learning is based on practical activities. In the research by Brawijaya, Simanjuntak, Wijoyo, & Herlambang (2024) it is reported that practical learning received very positive responses regarding student engagement in the learning process. However, it has not been explained what practical learning is appropriate for teachers to feel the need for cooperative learning tailored to students' subject areas, so that students are more enthusiastic about learning and understand the

benefits of studying mathematics, especially for vocational high school students in relation to their majors. Suppose this is not addressed immediately based on the results of the empathize stage. In that case, students will feel bored with learning, so teachers must recognize the need to design engaging lessons that align with students' daily activities (Riyadi, Jayanti, & Purwosetiyono, 2024).

Define Stage

The define stage is based on existing data and determines what actually happened (Saputra & Kania, 2022). This stage aims to analyze and understand the results from the previous stage, the empathize stage (Putra, Asfi, & Fahrudin, 2021), in which users and their needs are specifically stated in formulations using the point of view and how-might-we techniques (Dam & Siang, 2025).

Point of View

Point of view is a way to obtain information from users by making problem statements that are useful for generating design solution ideas according to the user's perspective (Riza, Sidharta, Rokhmawati, & Priharsari, 2022). And here are the results of the point of view from students and teachers:

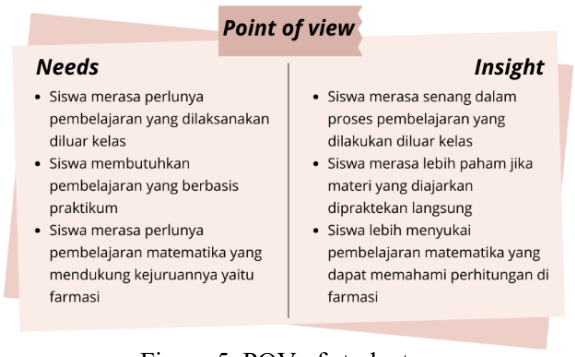

Figure 5. POV of students

From the students' point of view above, which the researcher analyzed from 50 respondents of class X pharmacy major students in the independent curriculum, among other things, students need mathematics learning that can be practiced outside the classroom, so that they can better understand the material taught by the teacher and support their ability in calculations in pharmacy.

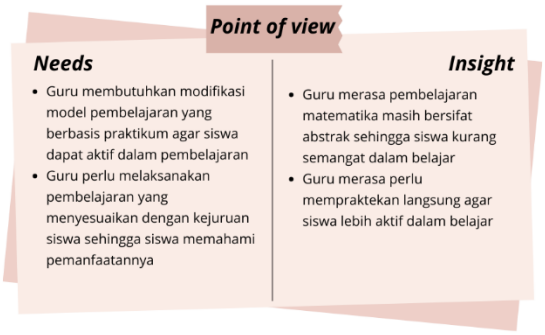

Figure 6. POV of teacher

From the teachers' point of view above, which the researcher analyzed from 6 respondents who are mathematics teachers teaching 10th grade in the independent curriculum, among other things, the teachers feel the need to modify the practical-based learning model so that they can engage students more actively in learning mathematics, enabling students to understand its application in the pharmacy major.

How Might We

How Might We is a method that allows us to transform a problem identified at the pain point into a question, enabling us to refresh our thinking and view every problem as one that can be solved (Suryadana, Sasongko, & Nugroho, 2023). Thus, with the how might we technique, it helps researchers to focus on solving the problems that have been concluded. Here is how we might proceed at the define stage:

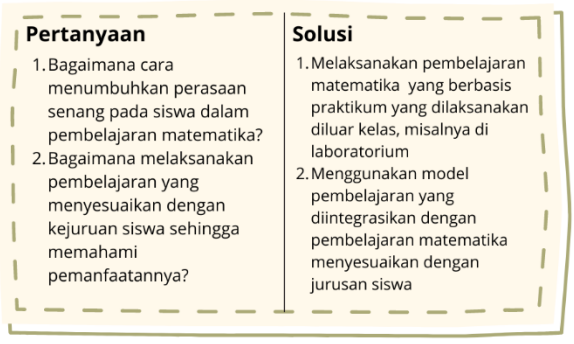

Figure 7. How might we

In the How Might We diagram above, the researchers analyze information about the needs of each problem and solution, and how to build each solution. In the first question, how to cultivate a sense of enjoyment in students during mathematics learning, the solution offered from the observed analysis is to implement practice-based or activity-based mathematics learning that students can directly practice outside the classroom, such as in a laboratory. In line with the research by Caig et al. (2013) and Lubis, Ginting, Munthe, & Rahmani (2023) which states that the learning process carried out outside the classroom, especially in mathematics subjects, greatly influences the learning outcomes achieved by students. And with this, this research explores the expectation that mathematics learning can be done outside the classroom, namely in a laboratory that supports their vocational skills.

Then, for the second question, which is how to implement learning by adjusting to the students' majors so that they can understand its application, especially in mathematics, the solution is to conduct mathematics learning integrated with mathematics learning adjusted to their majors. This is supported by research conducted by Sumandya & Widana (2022), which found that some vocational high school students have low interest in mathematics lessons unrelated to their chosen major, resulting in poor academic achievement. Therefore, this research can provide in-depth information regarding mathematics learning that is truly related to their major.

Ideate Stage- creating solutions

The Ideate stage is the stage where designers create several solution ideas Lindberg et al. (2010) based on the results or data collected from the empathize and define stages happened (Saputra & Kania, 2022). In the ideate process, a brainstorming session is conducted to gather diverse ideas from others to solve problems (Febriansari, Sarwanto, & Yamtinah, 2022). Here is the mind map from the brainstorming results, an overall depiction of the ideas and concepts incorporated into the image (Dam & Siang, 2025).

Figure 8. Mind map

From the mind map above, there are 2 main user needs that serve as a reference for researchers exploring integrated mathematics learning with a vocational-based learning model, namely, students who require learning conducted outside the classroom and vocational-based mathematics learning. Then, from the description of the learning model to be integrated, namely the teaching factory, which refers to the standards and procedures applicable in the industry and is conducted in an atmosphere similar to that of the industry (Fitrihana, 2018).

Then the strategy in mathematics learning integrated with teaching factory learning is: (1) Identify the mathematical concepts to be studied and their relation to students' vocational competencies; (2) Designing a learning plan that integrates mathematical concepts with practical activities in the Teaching Factory

And the implementation of integrated mathematics learning with teaching factory learning, namely: (1) The teacher demonstrates the application of mathematical concepts in practical activities at the Teaching Factory; (2) Students practice in groups; (3) Students discuss their experiences in applying mathematical concepts during practice and emphasize the importance of mathematical concepts in the workplace.

IV. Conclusion

Based on the problem exploration that has been conducted, the researcher designed mathematics learning integrated with teaching factory learning, referring to the standards and

procedures applicable in the industry and carried out in an atmosphere similar to that in the industry, to encourage students to be more active in learning mathematics, so that they understand how mathematics is utilized in the pharmacy major. The limitations of this study are that an integrated mathematics learning design using the teaching factory model has not yet been developed, so further research is needed during the trial stage to determine the effectiveness of the mathematics learning. Additionally, the design thinking method needs to be further maximized to explore students' needs with more data deeply.

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