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Development of Philosophy Based-Students Worksheet on the Matrix

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Abstract

This study focused on developing student worksheet (SW) based on philosophy on the topic of matrix operations, including an overview of its effect on students' conceptual understanding abilities of grade XI at Senior High School (SMA in Bahasa) IT Bina Ilmi Palembang. It discussed how the student worksheet produced could be valid, practical, and had potential effects. The method used was development research consisting of preliminary, prototyping and assessment phase stages. This student worksheet consisted of the history of the matrix (ontology), matrix operation procedures (epistemology) and implementation of the matrix (axiology). The results showed that the validity of the student worksheet amounted to 84.1% with a valid category and could be used with minor revisions. The practicality score at the small group stage was 87.8% with a very practical category. Statistical results showed that there was an increase in the average score of a significant test result of 59.06. This showed that there was a positive effect from the use of philosophy-based SW on students' conceptual understanding. Based on these results, the philosophy-based student worksheet developed was categorized as valid, practical, and effective in improving students' conceptual understanding ability on matrix material.

Keywords: Student Worksheet, Development Research, Matrix Operation

Abstrak

Artikel ini berfokus pada pengembangan lembar kerja siswa (SW dalam bahasa Inggris) berbasis filsafat pada materi operasi matriks, termasuk tinjauan pengaruhnya terhadap kemampuan pemahaman konsep siswa kelas XI di SMA IT Bina Ilmi Palembang. Membahas bagaimana SW yang dihasilkan dapat valid, praktis, dan menimbulkan efek potensial. Metode yang digunakan adalah penelitian pengembangan yang terdiri dari tahap pendahuluan, pembuatan prototipe, dan penilaian. SW dirancang memuat sejarah matriks (ontologi), prosedur operasi matriks (epistemologi), dan implementasi matriks (aksiologi). Hasil penelitian menunjukkan bahwa kevalidan SW sebesar 84,1% dengan kategori cukup valid dan dapat digunakan dengan revisi kecil. Skor kepraktisan pada tahap small group sebesar 87,8% dengan kategori sangat praktis. Hasil statistik menunjukkan bahwa terjadi peningkatan rata-rata skor hasil tes yang signifikan sebesar 59,06. Hal ini menunjukkan bahwa ada pengaruh positif dari penggunaan SW berbasis filsafat pada pemahaman konsep siswa. Berdasarkan hasil tersebut maka Lembar kerja siswa berbasis filsafat yang dikembangkan sudah terkategori valid, praktis, dan efektif dalam meningkatkan kemampuan pemahaman konsep siswa pada materi matriks.

Kata kunci: Lembar Kerja Siswa, Penelitian Pengembangan, Operasi Matriks

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INTRODUCTION

The ability to understand concepts is an important factor that must be achieved by students in learning activities. In fact, it is undeniable that the ability to understand students' mathematical concepts is still low until now (Zebua et al., 2020). Understanding the concept is needed because of the demands of 21st century education not only which involves aspects of skills and understanding in its implementation, but also emphasizes aspects of creativity, collaboration, and communication (Kasse &

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Atmojo, 2022). NCTM also states that understanding concepts is the basic goal of learning mathematics (Haji & Yumiati, 2019). When students understand mathematical concepts, they will easily solve problems in mathematics. The importance of understanding mathematical concepts is also seen in the first objective of learning mathematics according to the Ministry of Education, Culture, Research, and Technology (MoECRT, 2022). But the fact is that the conceptual error is one of the learning errors that often occur in schools (Augustine et al., 2020).

One of the mathematical topics that often occurs in mathematical concepts is the topic of Matrix. In general, matrix learning is closely related to number operations, but what happens in the field is that errors in operating numbers still often occur (Asdarina & Khatimah, 2021). The matrix is also a new topic known to students at high school level so that many students are still unfamiliar with the concepts given. The mistakes that most students make are they do not understand the concept of the matrix, forget the concept of the matrix and are less careful in carrying out calculation operations (Gustianingrum & Kartini, 2021). The type of error that students most often make on matrix questions is the wrong way to apply concepts when solving problems (Khairani & Kartini, 2021). Therefore, an update is needed in the learning process to overcome those existing problems, in this case by developing philosophy-based teaching material.

Philosophy is a knowledge related to the process of thinking deeply and seriously in solving the problems of life, including in the world of education (Nursikin, 2016). With philosophy, the knowledge will be studied down to the basic foundations so that the essence of each reality is obtained and helps individuals to think rationally, logically, and systematically (Sinaga et al., 2021). Philosophy consists of other disciplines that can be used in learning. One type of philosophy is the philosophy of mathematics. There are three philosophical studies of mathematics, namely aspects of ontology, epistemology, and axiology. The ontology aspect is closely related to the history of knowledge so that the history of mathematics is used as a means of reading literacy (Istiqomah & Somakim, 2022). In the epistemological aspect, it discusses how to acquire knowledge so that it can bring up aspects of 21st century skills such as critical thinking and problem solving, creative thinking, and training students' communication skills. While the axiological aspect is related to the usefulness of a science, so that this aspect is often associated with mathematics realistic in learning. Nova et al. (2022) also reveals that learning with a realistic approach is worth it on students' conceptual understanding. Therefore, philosophy-based learning includes the three philosophical aspects in mathematics that need to be applied to produce more meaningful learning so that it can strengthen students' understanding of concepts. One of them is developing teaching materials in the form of student worksheets.

Student worksheet is one of the learning tools that make it easier for teachers to carry out learning and help students in independent learning, understanding, and carrying out a learning activity (Apertha et al., 2018). Student worksheet helps students to be active in the learning process because it contains activities that involve students (Zulfah et al., 2018). The learning process using student worksheet can encourage students to understand the material more easily both individually and in groups, making

lessons not only centered on the teacher but also guiding students to actively participate in the learning process and become one of the factors that motivates students in learning mathematics (Pratiwi, 2021). Kolomuc et al. (2012) also reveals that the addition of pictures on student worksheet can help students understand the material taught. However, the fact is that the worksheets distributed in schools are still general in nature and mostly only contain a summary of the material. The material presented is usually instant without detailed explanations and there are no instructions for using the worksheet for teachers and students so that it does not attract students' enthusiasm in learning (Astuti et al., 2018).

In previous studies, there had been researches on the development of philosophy-based student worksheet on the material of conical space building (Arifin et al., 2021) on set material to see students' learning interest (Istiqomah & Somakim, 2022), on triangular congruence material to see student learning motivation (Pratiwi, 2021), and on algebraic form operation material to see students' concept of understanding ability (Nur'rohim, 2021). However, there was little research that focused on developing the philosophy-based student worksheets for high school students on matrix material. The development of philosophy-based student worksheet had not been developed and tested on students in Palembang. Therefore, this research aimed to develop a valid, practical, and effective philosophy-based student worksheet in improving students' conceptual understanding ability on matrix material in grade XI.

METHODS

Type and subject

This research employed the development study design with three stages: Preliminary, Prototyping, and Assessment phases (Akker et al., 2013). The Preliminary stage included the preparation stage and needs analysis. When preparing the experiment, the researchers administered permits to do research at schools. Then in the needs analysis, the researchers conducted an analysis of the students, the matrix material, and the curriculum. At the prototyping stage, student worksheet based on philosophy on matrix material was designed and developed. The prototype was validated by experts and students then tested in small groups. The prototype would still be improved depending on suggestions and feedback. The assessment phase followed, and its purpose was to determine the possible impact of the student worksheets created on students' conceptual understanding skills. This research involved three students for one to one, six students for small groups, and 15 students for a field test of grade XI at SMA IT Bina Ilmi Palembang.

Procedure

This research produced a student worksheet based on matrix materials to see students' conceptual understanding abilities. This study went through three stages: Preliminary, Prototyping, and Assessment Phase (Akker et al., 2013).

Preliminary

The preliminary stage included two stages, namely the preparation stage to determine the place of research and the analysis stage based on the 2013 curriculum, matrix material, activities, and expected learning objectives. The next stage was the prototyping stage where the worksheets for philosophy based on matrix materials that focused on developing content, constructs, and language were designed to produce the prototype I.

Prototyping

This stage was used to evaluate student worksheets that had been previously designed. This stage consisted of 4 stages, namely: (1) Self-Evaluation: This stage was done by evaluating student worksheets that had been designed in the previous stage by the researchers themselves. If there were errors in writing or otherwise, it would be revised first. The product that had been revised at this stage was prototype 1. (2) Expert Review: Prototype 1 results from the self-evaluation stage were validated by experts. The validation was processed by two mathematics education lecturers who taught history and philosophy of mathematics courses using validation sheets. The validity of student worksheets was reviewed based on the content and context of the matrix material, constructs that connected student worksheets with learning activities, and the suitability of the language used. Then, (3) One to one: the student worksheet test phase for 3 students from class XI.B based on the teacher's recommendation. This stage aimed to see the feasibility of the student worksheets that had been developed whether they were valid or not. This stage was tested directly on students. Comments and difficulties found during the test process were used to improve the student worksheet. The results of expert validation and one-to-one testing were called valid prototype II. (4) Small Group: this stage was done by testing prototype II to small groups in class XI.B who were different from the previous stage. Class selection was based on the teacher's recommendation where the class did not study the matrix material. Researchers made observations to see the process when students worked on a student worksheet. After that, students were given a practicality questionnaire consisting of several statements and provided comments and suggestions sheets. If there were suggestions, comments and difficulties faced by students, revisions were made to get a valid and practical worksheet. The result of this revision was in the form of prototype III.

Assessment Phase

At this stage, prototype III in the form of a valid and practical worksheet was tested on class XI.A students at SMA IT Bina Ilmi Palembang. The aim of this stage was to see the potential effect of philosophy-based student worksheets on matrix material on students' conceptual understanding abilities. Students were given a pretest before and posttest after working on a philosophy-based student worksheet.

Data collection and Analysis

The data collection used in this study are walkthroughs on the expert review phase, practicality questionnaires in small groups, pre-post tests on the assessment phase, and interviews to confirm the student's result were all data collection techniques. The assessment category is used on the validation sheet using a Likert scale with a score range of 1 (not good), 2 (good enough), 3 (good), and 4 (very good). The validation sheet can be reached by https://s.id/ValidationSheet. Then the calculation of the score that had been obtained by determining the percentage of the total score. Then the percentages were grouped based on the level of validity which is presented in Table 1 (Akbar, 2013).

Table 1. Validity criteria of SW

Validity (%)	Validity Criteria
$85 < V \leq 100$	Very Valid (can be used without revision)
$70 < V \leq 85$	Valid (usable with minor revisions)
$50 < V \leq 70$	Less Valid (recommended not to use because it needs major revision)
$0 \leq V \leq 50$	Invalid (should not be used)

If the validation results show valid or very valid criteria, then the student worksheets are revised based on the suggestions and comments from the validators. Otherwise, if the results are invalid, the student worksheets will be redesigned. After obtaining the validity of student worksheets based on Table 1, practicality data will be processed from the questionnaire distributed during the small group. The questionnaire contained 14 statements with 4 answer options (Strongly Agree, Agree, Disagree, and Strongly Disagree) consisted of seven positive statements and seven negative statements arranged based on practicality indicators which included ease of use, benefits, and attractiveness. The questionnaire was filled out by students individually. The questionnaire used was a Likert scale with practicality criteria presented in Table 2 (Pratiwi, 2021).

Table 2. Practicality criteria of SW

Practicality Level (%)	Practicality Criteria
$84 \leq PR \leq 100$	Very Practical
$68 \leq PR < 84$	Practical
$52 \leq PR < 68$	Practical enough
$36 \leq PR < 52$	Not Practical
$20 \leq PR < 36$	Very Impractical

The expected practicality criteria are above the moderately practical category (see Table 2). This will show that the student worksheets that have been designed are easy to use by students and in accordance with student needs.

Then the valid and practical student worksheet that had been through the expert review, one to one, and small group stages was tested on the research subject, class XI.A SMA IT Bina Ilmi

Palembang, totaling 15 students. This stage aims to see the ability of students' concept understanding on matrix material based on the results of pretests and posttests that have been given after learning using student worksheets. The category of students' conceptual understanding can be seen in Table 3 (Nur'rohim, 2021).

Table 3. Students' conceptual understanding abilities

Score	Students' Conceptual Understanding Abilities
$80 \leq S \leq 100$	Very good
$60 \leq S < 80$	Good
$40 \leq S < 60$	Enough
$20 \leq S < 40$	Low
$0 \leq S < 20$	Very low

The scores obtained by students during the test were processed and grouped based on the categories (see Table 3). The categories of students' concept understanding ability as shown in Table 3 during the pretest and posttest will be compared. This shows that the student worksheets that have been developed influence these students' abilities.

RESULT AND DISCUSSION

Preliminary

The first stage was preparation. At this stage, the researchers conducted a preliminary study of the student worksheet development plan, then determined the target school for the research, namely SMA IT Bina Ilmi Palembang. The researchers administered permits as well as school observations to determine research subjects, namely from class XI which consisted of 3 students for one to one and 6 students as small group stage subjects and determined the time of the study.

The second stage was the analysis stage which included analysis of the 2013 curriculum, matrix material, learning activities to be done, and analysis of the character of the research subject. Researchers s conducted student analysis with the help of a math teacher at SMA IT Bina Ilmi Palembang. The result of interviews showed that the enthusiasm of students often appeared when group learning was done. Students had never received learning using student worksheets. In addition, students did not study the matrix material before. In addition, the teacher said that class XI only consisted of two classes, namely XI.A and XI.B, so that the subjects for the one-to-one and small group stages would be chosen from class XI.B. while XI.A became the subject for the field test stage. The teacher also selected XI.B students who would be the research subjects based on their mathematical ability and availability. Furthermore, researchers s conducted a curriculum analysis, SMA IT Bina Ilmi Palembang using the 2013 curriculum for class XI. Based on the curriculum used, the matrix material was one of the materials studied in class XI in the odd semester. The last analysis was material analysis. In this study, the

researchers choose matrix material as the material used in developing philosophy-based student worksheets to see students' conceptual understanding abilities. This material was chosen because the matrix concept was a new material learned by high school students and a prerequisite for other materials.

Prototyping

At this stage, a philosophy-based student worksheet designed was contained of an ontology related to the history and definition of matrices, an epistemology related to how to gain knowledge and calculation of matrix concepts, and an axiology related to everyday life problems involving matrices. The design of student worksheet was started by determining the theme, color selection, and layout of the contents of the student worksheet. Furthermore, the indicators, learning objectives, instructions for working on student worksheets, choosing the context that was used as problem, and steps for working on student worksheets were formulated. The design of the contents of the student worksheet as a prototype I can be seen in Figure 1.

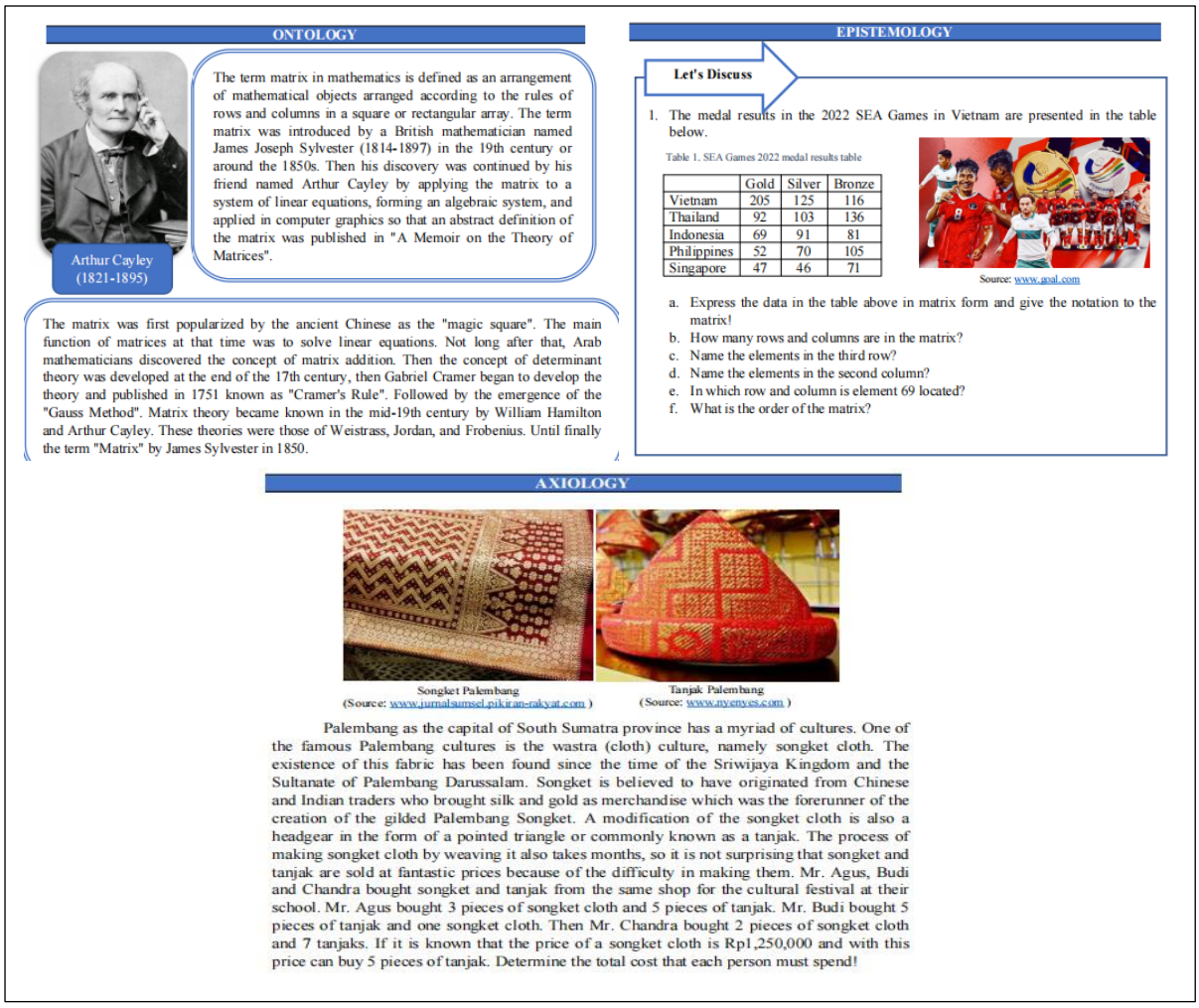

Figure 1. Prototype I of Student Worksheets

Self-Evaluation

At this stage, the researchers independently assisted by direction from the supervisor conducted an initial evaluation of the initial design of the student worksheet that had been developed starting from the cover page, color selection, writing errors, context selection, and suitability of content with learning objectives. Based on the results of discussions with the supervisor, the initial design developed was good enough and there was no revision so that the prototype I of the student worksheets developed was produced. The results of this stage obtained prototype I (see Figure 1). It shows that there was a history and definition of the matrix in the ontology part, then there was the context of the Sea Games used in the epistemology part, and the context of local wisdom using Palembang Songket and Tanjak as a problem. Songket is a type of traditional Indonesian woven fabric originating from Palembang, South Sumatra. Songket is woven by hand using gold or silver threads. Commonly used fabrics such as silk and cotton. A modification of the Songket fabric is also a headgear in the shape of a pointed triangle or commonly known as a Tanjak.

Expert Review and One-to-one

The results of Prototype 1 (see Figure 1) from the self-evaluation stage were validated by experts. The validation process was done by two mathematics education lecturers who taught history and philosophy of mathematics courses using validation sheets. While in terms of content, researchers used material that was in accordance with the curriculum used. In terms of language, the latest writing rules were used in accordance with The Perfected Spelling of Indonesian Edition V so they would not cause ambiguity from the student worksheet developed. This expert validation process was done by providing validation sheets to validators (see Table 4).

Table 4. Expert review result of the prototype I

Aspect	Validator		Total score
	I	II	
Content	11	11	22
Construct	15	18	33
Language	10	9	19
Average			0,8409

Based on Table 4, the validation sheet that was given to the expert obtained a percentage of 84,1% out of 11 indicators which showed that the philosophy-based student worksheet on the matrix material was valid with slight revisions. Based on comments and suggestions from expert validators such as improving the cover page, adding core competencies and basic competencies, and improving context and content layout. In line with this, the researchers also tested prototype I to students through one-to-one activities to see the opinions of students in working on the problems contained in the student

worksheet. This was done by asking for students' comments and suggestions as materials for revising the prototype I that had been developed.

Table 5. Comments/suggestions and revision of the prototype I

Validation	Comments/Suggestions	Revision
Expert I	Add core competencies and basic competencies on the student worksheet.	Core competencies and basic competencies have been added as commented.
	Add a magic square image in the ontology foundation section.	Magic square image added below the mathematician image.
	Try to use a single context, add an introduction to each sub-material, bring up the terms (communicative, associative, and distributive) before concluding.	In the epistemology section, one context is used, namely the acquisition of medals at the Sea Games, given an introduction at the beginning before entering the sub-material.
Expert II	Come up with the words commutative, associative, and distributive.	The words commutative, associative, and distributive appear in the matrix calculation operation section.
	Provide clear questions and customize the answer space under each question.	The space setting for student answers has been adjusted.
	Provide clues in the axiology section so that students can answer the problems given.	Instructions are given to direct students to answer problems in the axiology section.
Students	I am confused about the terms commutative, associative, and distributive in this let's conclude section. what should we write?	Students have difficulty understanding the commutative, associative, and distributive terms on the student worksheet because they have just heard the terms. So, an introduction to each term is given.
	How to solve this problem? what to write first	Students have difficulty in solving problems in the axiology section. So that direction is given in solving the problem

Based on Table 5, it is known that students did not understand the problem because they did not recognize new terms such as order, commutative, associative, and distributive because they had not been introduced in the introduction to the problem. Procedurally, students were able to work on matrix addition and subtraction problems but could not represent the mathematical model of the problem. Students were confused about answering questions in the axiology section. Based on comments, suggestions, and research observations, revisions were made to the student worksheet that had been developed. So, the researchers made improvements to the section, concluded the epistemology section, and provided instructions for solving the problems listed in the axiology section. After making improvements to the student worksheet, its components were adjusted based on the suggestions and

comments from experts and students at the previous stage. The revised results were presented in the form of prototype II.

Small Group

Small group stage was conducted offline so that students could discuss with their group friends. Researchers also made observations when students worked on student worksheets to see what difficulties were experienced, attitudes, and questions posed by students. Based on comments and suggestions from students, it was known that almost all students had given a positive impression but there was still a little confusion in solving the problem of the epistemology section in the multiplication part of two matrices. When working on student worksheet, students found it difficult to understand the meaning of the questions then the researchers directed them by making slight changes to the questions so that they understood better and asked them to return to have discussion to answer the questions. After being guided by the researchers and discussing with their friends, their group was able to solve the problems given. Based on the difficulties experienced by students, the researchers made a few revisions to the section so that students had a better understanding of the questions given. The results of the revision at the small group stage can be seen in Table 6.

Table 6. Results on the small group stage

Part of Student Worksheet	Before revision	After Revision
Epistemology	1. Can the matrices below be multiplied? (If so, write down the order of the result in matrix form S) a. $P \times Q =$ b. $P \times R =$ c. $Q \times R =$	1. Can the matrices below be multiplied? (If so, write down the order of the result in matrix form S) a. $P_{2\times2} \times Q_{3\times2} =$ b. $P_{2\times2} \times R_{2\times3} =$ c. $Q_{3\times2} \times R_{2\times3} =$

After working on the student worksheet, students were given a practical questionnaire to see that the student worksheet developed was categorized as practical. The results of the questionnaire scores obtained an average percentage of 87.8%. This percentage of practicality showed that the student worksheet developed was categorized as very practical to use. Furthermore, revisions were made to the student worksheet based on students' comments/ suggestions to produce prototype III which could be declared as a valid and practical product. Significant changes in the student worksheet can be seen in the ontology and epistemology sections in Figure 2.

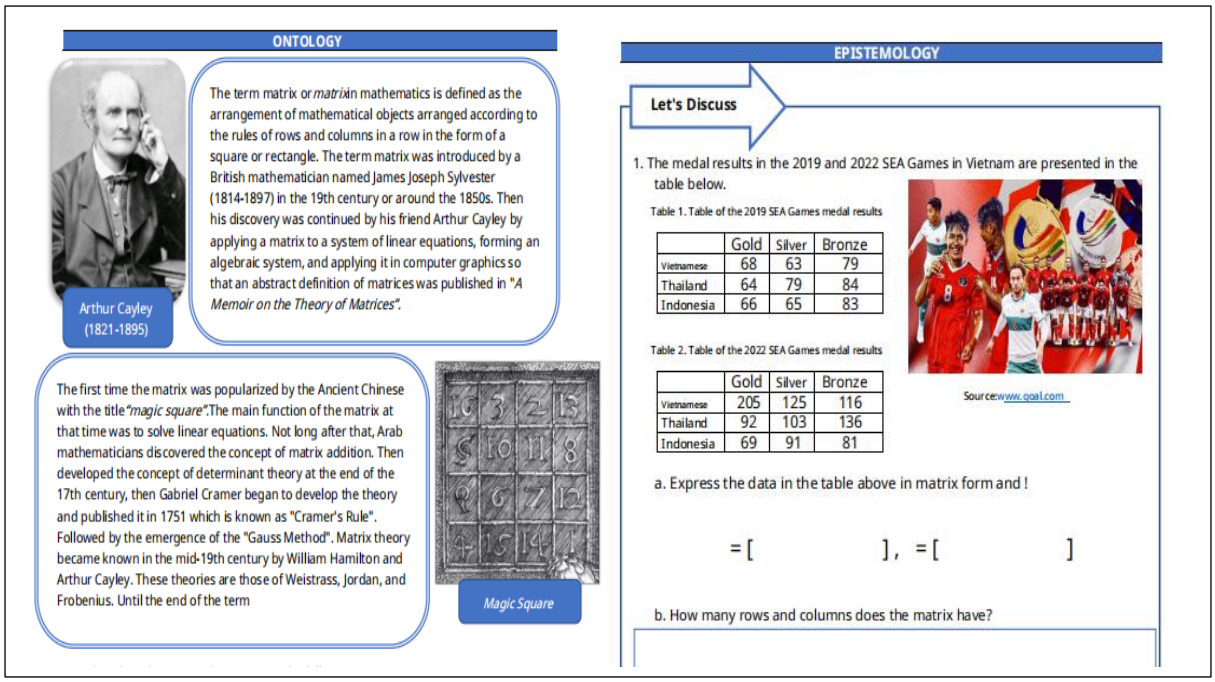

Figure 2. Prototype III of student worksheet

Assessment Phase

The assessment phase was the final stage of the research. This stage was conducted in two face-to-face learning meetings. This stage was aimed to determine the potential effect of the student worksheets that had been developed, namely students' conceptual understanding ability. The ability to understand students' initial concepts on the matrix material was seen from the results of the pretest. All students as the research subjects still had low conceptual understanding abilities. After completing the student worksheet, students were given a posttest related to the matrix material.

Pretest and posttest questions tested to students consisted of five questions with different levels. The five questions included history, calculation operations, and problem solving with matrix concepts. Before being given treatment with student worksheet, students did not know the mathematician who invented the matrix and did not understand the concept of matrix in detail. Figure 3 shows question 1 and question 2. Question 1 contained the history of the matrix, and all students were not able to answer pretest question 1 correctly but after giving student worksheet, all students were able to answer posttest question 1 correctly. Furthermore, question 2 contained an understanding of matrix concepts related to rows, columns, and orders. Students were not able to write the order of symbols correctly in the pretest question but in the posttest it was correct. And questions related to the application of matrices in everyday life, students were not able to answer these questions at the time of the pretest. While after learning by using student worksheets, most students could answer these questions correctly.

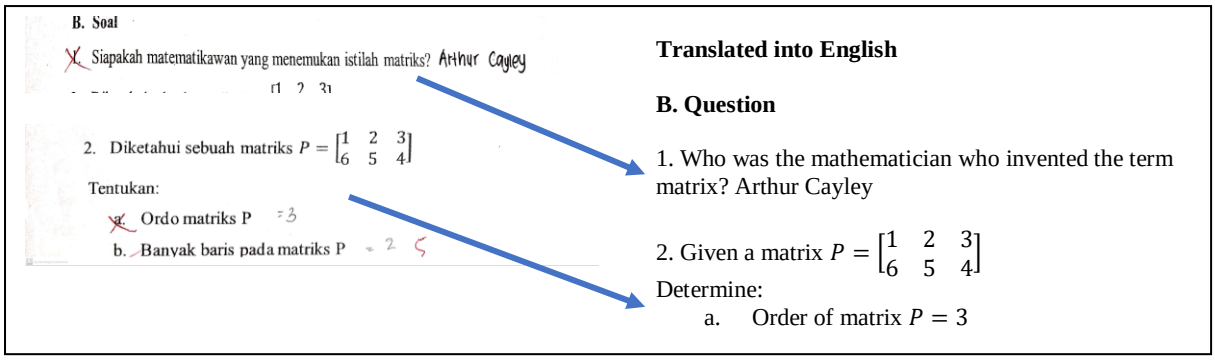

Figure 3. Students' pretest answer

Figure 3 shows that students were not able to answer low-level test questions well. Question 1 asked about the history of matrices, namely mathematicians who discovered the term matrix. Unfortunately, because Arthur Cayley was more well known in the process of discovering matrices, students wrote the name of that mathematician. Meanwhile, the one who discovered the term matrix was James Joseph Sylvester. Furthermore, question 2 related to the basic concept of the matrix, namely the order. Students were wrong in writing the order in the matrix. This showed that the initial understanding ability of the matrix concept was still low.

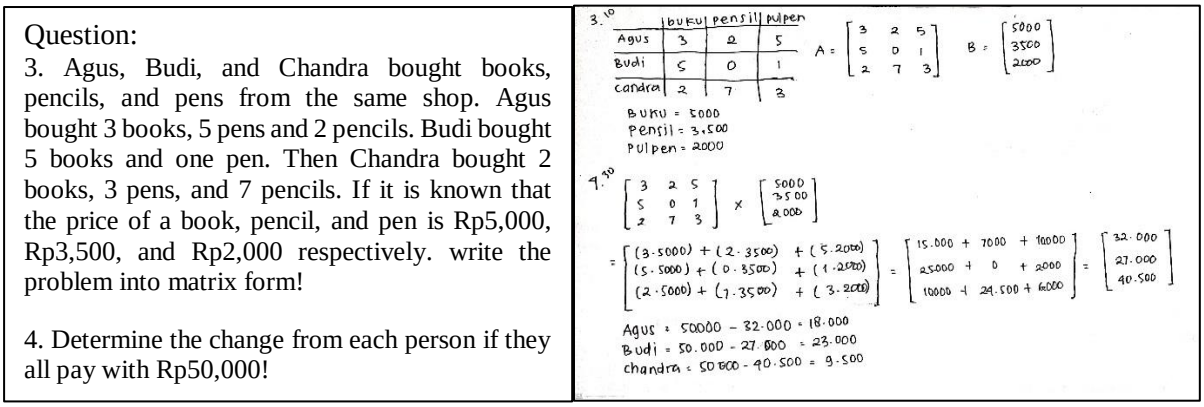

Figure 4. Students' posttest answer

Figure 4 contained problem solving questions that must be solved using the matrix concept. Students seemed to be able to represent the problem in a mathematical model. They used the help of a table to put the price of each item bought by Agus, Budi, and Chandra in the problem. Then, using the concept of multiplication of two matrices to solve the problem. Figure 4 shows the students' answers on the posttest questions with the highest level being tested (C3) analyzing. Problems lied on questions number 3 and 4 and must be solved using the matrix concept. During the pretest, no one could answer those questions. However, after being given learning treatment using philosophy-based student worksheet, it appeared that students were able to interpret the meaning of the questions, modeled them mathematically and used matrix concepts in solving problems. This was in accordance with the research conducted by Apriani et al (2017) that learning using SW has a positive impact. In Figure 4, students

tried to make a matrix shape with the help of tables, then solved it according to the procedure they had learned. This demonstrated that the generated student worksheet had a beneficial impact on students' conceptual understanding skills (Laili et al., 2019).

Table 7. Data of students test result

Criteria	Pretest		Posttest	
	Frequency	Score average	Frequency	Score average
Very good	0	0	10	91,5
Good	0	0	5	68,2
Enough	3	50	0	0
Low	5	23	0	0
Very low	7	15	0	0

Table 7 shows the results of the average student scores before and after working on the philosophy-based student worksheet on matrix material. The results of the pretest scores were 20% of students (3 students) whose initial concept understanding ability was categorized as enough criteria. Meanwhile, 33.3% (5 students) and 46.7% of those (7 students) who had low ability still had very low initial conceptual understanding ability. This meant that almost all students who had initial concept skills on matrix material were still categorized as low or even very low. This was because many students were still unable to apply concepts in solving problems in everyday life even though the ability of these mathematical concepts was used as a foundation in understanding higher material (Munasiah et al., 2020). Indicators of the application of a matrix concept in this study were presented in the form of story questions, in accordance with a study which stated that students still had difficulty in understanding story problems (Triwibowo et al., 2018). For this reason, as the first step to improve the ability to conceptual understanding, students were given more interactive learning and let students learn the matrix material from the bottom. Mathematics teaching should lead to students' mastery of mathematical concepts (Novitasari & Leonard, 2017).

After being given a learning treatment using a philosophy-based student worksheet, the data in Table 7 shows that the ability to understand students' concepts on matrix material had increased. 67,7% of students (10 students) had very good concept skills and 33,3% of students (5 students) had good results. So that the total average score obtained by students reached 83.73%. During the work on student worksheet, students were guided to discuss in groups. On ontology, almost all students were able to answer questions related to literacy from the history of the matrix. Students can literate well based on what learning design the teacher provides (Sultan et al., 2021). This states that learning with student worksheet influences students' understanding of mathematical concepts (Laili et al., 2019). According to Kolomuc et al (2012), some of the images presented in the student worksheet also helps students to understand the concept of the matrix being taught. However, to strengthen the argument that students really understand the material and feel helped after using the student worksheets, interviews were conducted.

Based on the results of interviews with three students according to the teacher's recommendation that the three students had high, medium, and low mathematical abilities. It was known that they found it helpful for learning activities working in groups using student worksheets because they could discuss and understand the matrix concept easily. Students felt that problems with the context of local wisdom helped them in understanding concepts (Deda & Maifa, 2021). Students admitted that sometimes they were still mistaken in operating the numbers in the matrix due to time constraints and lack of thoroughness (Gustianingrum & Kartini, 2021). In the student worksheet, there were also questions that directed students to gain knowledge so that they could conclude the answers to these problems easily. They also said that the matrix material was no longer difficult to learn (Khairani & Kartini, 2021).

Philosophy-Based Student Worksheet

The developed philosophy-based student worksheet was valid in content, construct, and language (Figure 2). Then, it was easy for students to use (practical) and effective in improving students' conceptual understanding. This research developed philosophy-based student worksheet that was oriented to the needs of students, the applicable curriculum, and improved 21st century skills in students. Philosophy-based learning helps students to understand the material deeply (Sinaga et al., 2021). In addition, the developed student worksheet can support the learning process and help students to understand the material more easily. Student worksheets are usually in the form of instructions, steps to complete the task (Apertha et al., 2018). The advantage of using worksheets is that it makes it easier for educators to implement learning activities and for students, they can learn independently as well as understand and perform written assignments. Based on this discussion, it shows that it is important to develop philosophy-based student worksheet. This is strengthened by previous findings which state that philosophy-based student worksheets are effectively used to improve students' conceptual understanding (Nur'rohim, 2021).

The limitation of this study was the use of a small number of research subjects, so further research will be needed to develop student worksheets for other materials. The development of this student worksheet was expected to help students in learning, especially understanding matrix material. In addition, teachers can use this student worksheet in the learning process to improve students' conceptual understanding ability.

CONCLUSION

The product produced in this study was student worksheet on matrix material which included 3 philosophical foundations, namely the ontology related to the history of the matrix, the epistemology related to the process of obtaining concepts and understanding of matrix operations, and the axiology related to the application of matrices in everyday life. Based on the results of data analysis that had been

done, it was known that the developed student worksheet was included in the valid and practical categories. The developed student worksheet also had a potential effect on students' understanding of mathematical concepts. It was known that students' conceptual understanding after using this student worksheet was categorized as very good with average score 83.73. The use of this philosophy-based student worksheet was also a new thing for them, and they were more interested in the activities in the student worksheet that led them to think. Some of them still experienced errors in answering the questions because students were less careful in operating the matrix and interpreting the problem. The use of simple numbers and contexts that correspond to daily life were used as an introduction for students to current phenomena and helped them to get closer to solving problems.

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