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Development of a MatLab Mobile-Assisted Computation-Integrated Student Worksheet on Elementary Row Operations Material

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Abstract

Row Elementary Operation is one of the lecture materials in the S-1 Mathematics Education study program. Some students experience difficulties with the material, so learning media are needed to help them master it, namely student worksheets. The purpose of the research is to describe the process of developing computationally integrated student worksheets assisted by mobile MatLab in the Matrix Algebra course and to describe the validity and practicality of the developed worksheets. This type of research is research and development, where the products developed in this study are mobile MatLab-assisted computationally integrated student worksheets on elementary row operations material. The development model used is the Multimedia Development Life Cycle (MDLC). Based on the research and development carried out across the concept, design, material collection, manufacture, testing, and distribution stages, the student worksheets developed are highly valid and practical. A limitation of this research is that it does not test the product's effectiveness. This research implies that, given the product's very valid and practical results, further research can be carried out to test its effectiveness, and it can then be widely used in learning.

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INTRODUCTION

Operation Row Elementary (ORE) is one of the materials in the Matrix Algebra course. Matrix algebra is included in the basic courses that students must master because it is a prerequisite for other courses, such as Elementary Linear Algebra and Algebraic Structures. Therefore, students need to have a high level of understanding in the Matrix algebra course (Maharaj, 2015; Ndlovu & Brijlall, 2015).

Matrix algebra is very important to master, but some students still have difficulties. Based on the author's experience teaching this course, students are not yet skilled at performing the ORE procedure to determine the solution to a system of linear equations. (Priwantoro & Fahmi, 2021) also found the same problem. This can be seen from the results of the Final Semester Examination. Some students do not perform the procedure step by step in ORE, so the ultimate goal of determining the solution to a system of linear equations has

not been achieved. This is due to the need for a clear, complete understanding of ORE and the many procedural steps students must follow.

Educators — lecturers, in this case — can make it easier for students to understand material by using learning media. Learning media are tools used to convey learning materials to students (Baihaki et al., 2022; Djamilah & Puspitorini, 2021; Maulida et al., 2023; Ulfah et al., 2024). Lecturers must assess the condition of students' facilities in the classroom to optimize the use of learning media. In addition, learning media help encourage students to learn properly.

The development of technology is currently increasing rapidly across all spheres of life, including education and learning. The existence of technology is very helpful in implementing the learning process (Cloete, 2017; Raja & Nagasubramani, 2018). Through technology, learning will become more varied (Kyle et al., 2022; Rizvi et al., 2020). The development of technology makes it easier for a lecturer to use media that makes lectures more attractive to students.

By leveraging current technology, lecturers can improve students' understanding by using learning media in the form of computationally integrated student worksheets. This student worksheet combines print worksheets for students to write on with mobile MATLAB integration to check student answers. The student worksheet provides clear, practical steps for performing ORE. The technology used is to integrate student worksheets with mobile MatLab. MatLab (Matrix Laboratory) is software that can process numbers, syntax, and matrices, integrating flexible computing and programming (Akan & Chaparro, 2024; Cahyono, 2013; Kurasov, 2020; Moler & Little, 2020). In addition, MatLab is an application that can accurately calculate matrices because it provides an interface that greatly helps users, especially with calculations (Septianawati et al., 2022). In MatLab, a program can be developed to find solutions to complex linear equations using the ORE method.

There has been research on student worksheets (Norhaliza et al., 2022), spreadsheet-assisted computing integrated student worksheets (Sari & Sulisworo, 2021), learning modules using MatLab (Hidayatullaily et al., 2022; Septianawati et al., 2022), and IT-based textbooks (Gella & Bien, 2022). However, there is no research using mobile MatLab in college-level mathematics. The novelty of this research is the use of mobile MatLab in the worksheets of mathematics education students. Thus, this student worksheet integrates technology, making it more interactive, helping students understand the concept of ORE, and allowing them to easily recheck their answers.

Based on the explanation above, it is necessary to develop student worksheets integrated with mobile MatLab computing to maximize students' abilities. Therefore, in this study, the development of student worksheets integrated with mobile MatLab computing for ORE material will be carried out. The purpose of this study is to describe the process of developing mobile MatLab-assisted computational integrated student worksheets on ORE material and to describe the validity and practicality of the developed student worksheets.

METHODS

This research is development-oriented, with the product developed in this study being a student worksheet integrated with mobile, MatLab-assisted computing in the Matrix Algebra course. This research and development design falls under level 4 research and development, in which research and testing are conducted to develop products that do not yet exist (Sugiyono, 2017). The development model used is the Multimedia Development Life Cycle (MDLC). The MDLC cycle can be seen in Figure 1 (Binanto, 2010).

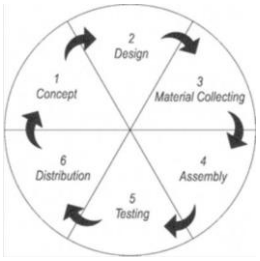


Figure 1 MDLC Development Cycle

There are six stages in the MDLC development cycle. The first stage is concept. This stage is the initial stage in the MDLC cycle. The concept stage begins by defining the product you want to make, its purpose, and its users. The second stage is design. The design stage is when detailed product specifications are created. At this stage, a student worksheet framework integrated with mobile MatLab computing will be made. The third stage is material collecting. This stage involves collecting materials in accordance with the needs of the student worksheets to be made. The fourth stage is assembly. This stage is the one where the entire student worksheet is created. The student worksheets are made based on the previous design and material collection stages.

Furthermore, the fifth stage is testing. There are two types of testing: alpha and beta testing. Alpha testing was conducted by material and media experts, namely mathematics education lecturers, to assess the validity of the products developed. Meanwhile, the beta test is conducted twice by users, namely, small and large trials. The small trial was conducted on three students who had taken the Matrix Algebra course to check whether the student worksheet could be used properly, and calculate the level of practicality, while the large trial would be conducted in one class where the student worksheet was used during learning activities for the Matrix Algebra course in the Mathematics Education Study Program to determine the level of practicality. This test was carried out in the even semester of the 2023/2024 academic year. The last stage is distribution. Distribution is the last stage in the development cycle.

In this research and development, researchers used a questionnaire instrument with a Likert scale to obtain the validity and practicality of the student worksheets made. The questionnaire used was adopted from a research questionnaire (Pratama & Waskitoningtyas, 2020). Indicators in media expert validation are about the appearance and use of mobile MatLab, while indicators in material expert validation are about the suitability of the content of the material on student worksheets with learning objectives. The practicality test indicator measures the ease with which users use student worksheets. The Likert scale is used as a reference point in preparing the questionnaire. The Likert scale has five response options (Sugiyono, 2017). Furthermore, the data analysis is aimed at assessing the validity and practicality of the learning media developed. The explanation is as follows.

The validity test uses the percentage validity formula: the total expected score divided by the total empirical score, then multiplied by 100%. The result of the calculation is the validity percentage. The results are then interpreted according to the categories in Table 1 (Akbar, 2013).

Table 1 Criteria Validity

Criteria Validity	Validity Level
85.01% – 100%	Very valid
70.01% – 85%	Valid Enough
50.01% – 70%	Less valid
1.00% – 50%	Invalid

The practicality test uses the following formula.

$$P = \frac{\sum F}{N \times I \times R} \times 100\% \quad \ldots (1)$$

Note:

P = Practicality percentage
$\sum F$ = Total score of all respondents
N = Number of respondents
I = Maximum score
R = Number of aspects assessed

Then the criteria for practicality are determined based on Table 2 (Ismail, 2023).

Table 2 Criteria for Practicality

Criteria Practicality	Practicality Level
81% - 100%	Very practical
63% - 80%	Practical
44% - 62%	Less practical
25% - 43%	Not practical

RESULTS AND DISCUSSION

Concept

The product made is a student worksheet integrated with mobile MatLab-assisted computing on ORE material. The material presented in this student worksheet includes the solution of a system of linear equations using ORE with the Gauss elimination and Gauss-Jordan elimination methods. The purpose of making products is to support researchers' efforts to increase students' understanding and learning independence in lectures, while product users are Matrix Algebra course participants, namely second-semester students of the Mathematics Education Study Program at Muhammadiyah University of Banjarmasin.

Design

At this stage, a student worksheet framework integrated with mobile MatLab computing is made. The student worksheet consists of a cover page, learning objectives, student identity, filling instructions, a barcode that directs to video tutorials on the use of mobile MatLab and MatLab program syntax, material, sample problems, practice problems, conclusions, evaluation, references, and a quote. The sample problem contains procedural steps in solving a system of linear equations using ORE. In the exercise problem, a blank column is provided at each step for students to write the steps of the answer according to the given procedure. In the evaluation, the problems are given only without guidance on the procedural steps for solving the system of linear equations. At the end of the exercise, problems, and evaluation, students were asked to watch the tutorial video given and enter the MATLAB program syntax on their respective mobile phones. Then, using MatLab mobile, students checked the solution of the system of linear equations that they had done before.

Material Collecting

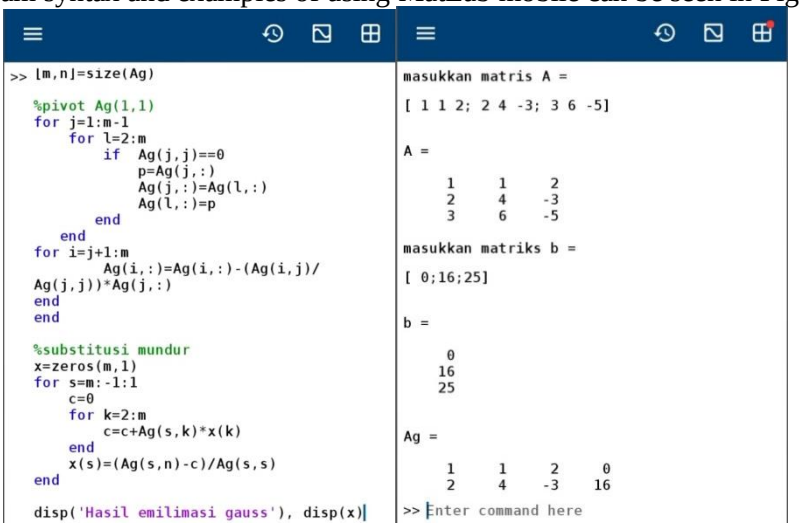
Materials needed include images, text, and computational programs, either ready-made or still in need of modification. Materials in the form of images are made using the Canva graphic design application (Paling et al., 2024), material and sample problems are quoted from several references, and program syntax in mobile MatLab is modified and adjusted to the needs of student worksheets.

Assembly

The student worksheet creation stage uses the Canva application to design worksheets and MatLab mobile to integrate worksheets with computing. The cover page of the student worksheet includes the institution's name and logo, the material title, the author's name, the course name, and the year of production. The home page contains learning objectives, student identity, and instructions for completion. The cover page and home page can be seen in Figure 2.

Figure 2 Cover page and home page of student worksheet

On the home page there is a barcode that leads to a video tutorial on the use of MatLab mobile and MatLab program syntax. Video tutorials are uploaded on YouTube. The MatLab program syntax and examples of using MatLab mobile can be seen in Figure 3.



```
>> [m,n]=size(Ag)

  %pivot Ag(1,1)
  for j=1:m-1
      for l=2:m
          if  Ag(j,j)==0
              p=Ag(j,:)
              Ag(j,:)=Ag(l,:)
              Ag(l,:)=p
          end
      end
  for i=j+1:m
          Ag(i,:)=Ag(i,:)-(Ag(i,j)/
  Ag(j,j))*Ag(j,:)
  end
  end

  %substitusi mundur
  x=zeros(m,1)
  for s=m:-1:1
      c=0
      for k=2:m
          c=c+Ag(s,k)*x(k)
      end
      x(s)=(Ag(s,n)-c)/Ag(s,s)
  end

  disp('Hasil emilimasi gauss'), disp(x)
```

```
masukkan matris A =

[ 1 1 2; 2 4 -3; 3 6 -5]

A =

     1     1     2
     2     4    -3
     3     6    -5

masukkan matriks b =

[ 0;16;25]

b =

     0
    16
    25

Ag =

     1     1     2     0
     2     4    -3    16

>> Enter command here
```

Figure 3 MatLab program syntax and example of using MatLab mobile

Furthermore, the material and sample problems of the solution of linear equations using ORE. The text of the materials and sample problems was typed directly into Canva. While the equation is typed in Microsoft Word, it is converted to an image and pasted on Canva. A snapshot of the materials and sample problems created can be seen in Figure 4.

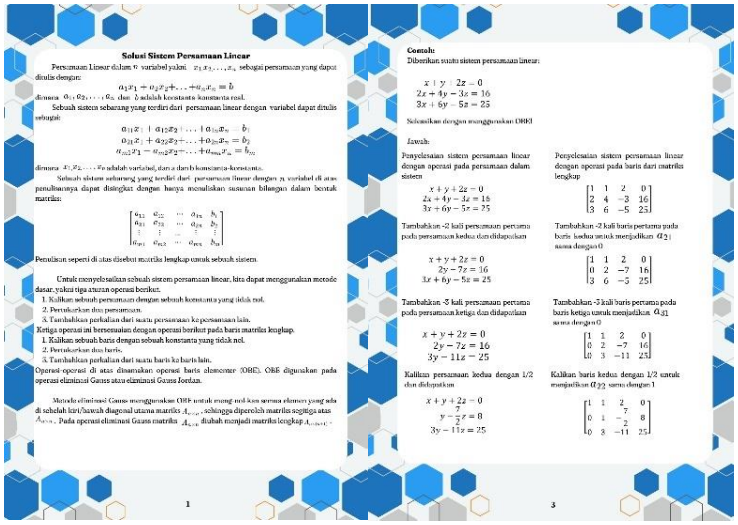


Figure 4 Snippets of material and examples of student worksheet questions

The exercise questions and evaluation also use both Canva and Microsoft Word. In the exercise questions, there is still a step-by-step guide to determine the solution of the system of linear equations, while the evaluation is only given a blank column to answer. A snapshot of the exercises and evaluations can be seen in Figure 5.

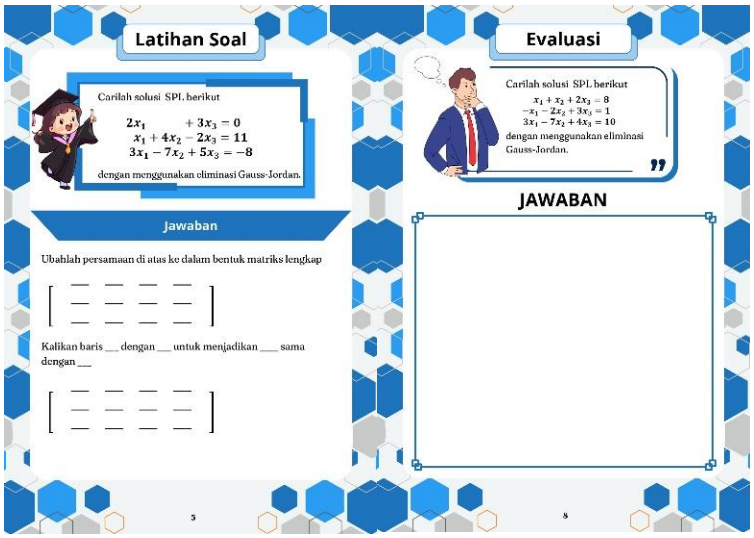


Figure 5 Snapshot of practice questions and evaluation of student worksheets

Finally, reference and quote. The references written down are only those used in this student worksheet (Anton, 1987; Riyana et al., 2022). References and quotes can be seen in Figure 6.

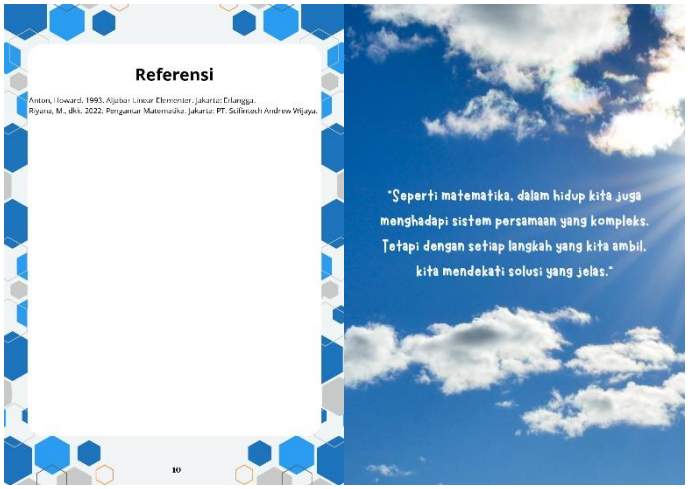


Figure 6 Reference and quote on student worksheet

Testing

In the Alpha test, the assessment results of 1 media expert regarding the appearance and use of mobile MatLab obtained a validity percentage of 96.05%, indicating very high validity. The results of the media expert assessment are shown in Table 3.

Table 3 Media expert assessment results

Number	Indicator	Score
1	The use of fonts and font sizes in this Student Worksheets (SW) is appropriate so that it looks attractive to students.	4
2	This SW has consistency in the use of spaces, titles, and typing of material	3
3	The font size used in this SW is not too large or too small so that it can be read clearly.	4
4	This SW has clarity of writing or typing	4
5	This SW has accuracy in the arrangement of paragraphs in the learning description	4
6	The color of the letters used is appropriate.	4
7	The cover of the SW has an attractive design and color.	4
8	This SW has an attractive appearance.	4
9	This SW has an interesting typing layout.	4
10	Presentation of the SW is equipped with pictures, videos, and illustrations.	4
11	The SW has accuracy in the placement of pictures, videos, and illustrations.	4
12	The size of the images and illustrations is appropriate (not too big or too small).	3
13	The presentation of images and illustrations on the SW is clear and not blurry.	4
14	Images and illustrations on the SW are in accordance with the material studied so that they can support student understanding.	3
15	The use of decoration as a background does not interfere with the title, text, and page numbers.	4
16	This SW uses a simple and user friendly display.	4
17	The barcode on the SW directs to the tutorial video.	4
18	Video tutorials explain the proper use of mobile MatLab.	4

Number	Indicator	Score
19	The SW uses the right color	4
	Total	73
	Percentage	96,05%
	Criteria	Very Valid

Furthermore, the assessment of 1 material expert regarding the suitability of the content of the material on the student worksheet with the learning objectives obtained a validity percentage of 94.74% which means very valid. The results of the material expert assessment can be seen in Table 4.

Table 4 Results of material expert assessment

Number	Indicator	Score
1	The material on this SW refers to the semester learning plan.	3
2	The material on this SW supports the learning outcomes to be achieved in the Matrix Algebra course.	4
3	This SW contains learning objectives.	4
4	The learning objectives in this SW are in accordance with the semester learning plan.	4
5	The material in this SW is clear and complete.	4
6	The material presented in this SW is easy to understand.	3
7	In the SW there are sample questions, practice questions, and evaluation.	4
8	The questions in this SW can measure the achievement of learning objectives.	4
9	Completion of sample problems is appropriate and in accordance with the questions given.	4
10	This SW has language conformity with EYD.	4
11	This SW uses language that is communicative.	4
12	The language presented on this SW can be understood and read by students.	3
13	The sentences on this SW are presented clearly and are not double-meaning.	4
14	The use of punctuation marks (periods, commas, etc.) on this SW is appropriate.	4
15	The use of capital letters on this SW is appropriate.	4
16	Question sentences and command sentences in this SW can be understood easily.	4
17	The sentences used in this SW have involved students' logical thinking skills.	3
18	In this SW, there are pictures, illustrations, and video tutorials to support student understanding.	4
19	In this SW, there are supporting module presentations in the form of filling instructions and a list of references.	4
	Total	72
	Percentage	94.74%
	Criteria	Very Valid

The combined validity is 95.40%, indicating that the product is highly valid and can be used, but only needs minor revisions based on the validator's comments and suggestions. The product was further revised based on several comments and suggestions from the validators. The following in Table 5 contains the comments and suggestions given and the improvements made.

Table 5 Comments, suggestions, and improvements

Number	Comments and Suggestions	Improvements
1	The diagonal matrix form at the beginning of the material needs to be written down $\begin{matrix}1 & 0 & 0\\0 & 1 & 0\\0 & 0 & 1\end{matrix}$ so that it can lead to the operations that students must perform in order to go to the diagonal matrix output.	The diagonal matrix has been written $\begin{matrix}1 & 0 & 0\\0 & 1 & 0\\0 & 0 & 1\end{matrix}$ at the beginning of the material.
2	The SW needs to elaborate on how to obtain "add -2 times the first row to the second row," for example, to zero a_{21}. The same goes for the others.	Each step of the solution in the example problem is given the goal of creating a zero unit element in each row or column of the matrix.
3	References need to be added, adjusted to the semester learning plan.	Not revised, because not all references sourced from the semester learning plan can be used in the material in this student worksheet.

Then, during the beta test, practical testing was carried out with users twice to assess ease of use of student worksheets, namely a small trial involving 3 students and a large trial involving 8 students. The results of the assessment in the practicality test can be seen in Table 6.

Table 6 Practicality test assessment results

Number	Indicator	Small	Large
1	In this SW there are instructions for filling out the SW.	12	32
2	I can understand the instructions for filling out this SW easily.	10	28
3	The instructions for filling out the SW help me in filling out this SW.	11	30
4	The material in this SW is clear and complete in accordance with the material on the solution of the linear equation system.	12	30
5	I can understand the material presented in this SW.	11	28
6	There are practice questions and evaluations in this SW.	12	32
7	The questions presented are in accordance with the material studied.	12	31
8	There are pictures, videos, and illustrations that support my understanding.	10	30
9	The barcode on the SW directs to video tutorials that can be accessed easily.	12	30

Number	Indicator	Small	Large
10	I can access the tutorial video through my cellphone.	12	31
11	The explanation in the video tutorial about using mobile matlab is clear and understandable.	11	27
12	The cover of the SW has an attractive design and color	9	29
13	This SW has an attractive appearance.	11	28
14	This SW has an interesting typing layout.	11	31
15	This SW has accuracy in the placement of images, videos, and illustrations.	9	28
16	The size of the images and illustrations is appropriate (not too big or too small).	10	31
17	The images and illustrations are clear and not blurry.	9	30
	Total	184	506
	Practicality Percentage	90.20%	93.01%
	Practicality Level	Very practical	Very practical

In the small trial, students were able to fill in the SW according to the instructions and achieved a practicality of 90.20%, which falls within the level of practicality and is very practical. In the large trial, the SW was used in one meeting, and students then completed the assessment via the questionnaire. In the implementation of this large-scale trial, a percentage of practicality of 93.01% was obtained with a very practical level of practicality. As a whole, the practicality of this product is included in the level of very practical, with a percentage of 91.60%.

Furthermore, students also gave some positive comments related to the learning media that had been made, including the following:The MatLab -integrated SW is very good, the readability of the SW is very clear, the ORE steps used make it easier to understand the material of the linear equation system, and the design of the SW is good. Meanwhile, students also gave suggestions, including the following: qoute on the last page, write the source, pictures of some matrices and equations are less clear, some students are constrained in installing and using the MatLab application on their gadgets, and fix some typos on the SW, especially in typing equations. Students gave some of the suggestions above because during the trial test a few mistakes were found in the answer writing in the example problem section. After conducting the practicality test, the student worksheet was revised to correct writing errors.

Distribution

At the distribution stage, the SWs are uploaded on Google Drive, then the link is shared. This can be used for further research. The Google Drive link that contains the SW file that has been made is https://bit.ly/FileLKMAljabarMatriks and can also be accessed via the QR code in Figure 6.

Figure 6 QR code file of matrix algebra student worksheets elementary row operation material

Based on the research and development that has been carried out, the process of developing mobile MatLab-assisted computational integrated student worksheets in the Matrix Algebra course using the Multimedia Development Life Cycle (MDLC) development model, which consists of several stages, namely the concept, design, material collection, manufacture, testing, and distribution stages, it is obtained that the student worksheets that have been developed are included in the level of validity very valid with a percentage of 95.40%. This means the learning media, in the form of student worksheets, are valid; only minor revisions are needed. Based on research (Agustina et al., 2021), the validator's assessment indicates that the student worksheets meet the indicators and are suitable for use. Student worksheets that are declared valid are then suitable for testing in learning, in this study, namely the practicality test (Puspasari & Puspasari, 2019; Yaden, 2017).

In the practicality test, a very practical level was obtained with a percentage of practicality of 91.60%. This means the student worksheets can be practical for students in the learning process. Then, with a level of practicality that is very practical, it can be inferred that the worksheet can be used easily in classroom learning situations or independently by students. Overall, the worksheets produced are valid and practical; this aligns with research (Anggraeni et al., 2021; Chotimah, 2021; Pratama & Waskitoningtyas, 2020), which indicates that products deemed valid and practical are feasible and can be used in learning activities. Furthermore, Astuti (2021), Hanifah (2021), and Nasrullah et al. (2018) stated that the use of worksheets can facilitate students' interaction with the material provided and make it easier for lecturers to conduct the learning process.

In addition, students actively ask questions during the lecture. Previous research (Choirudin et al., 2021; Nareswari et al., 2021; Norhaliza et al., 2022; Ulfah et al., 2024) also found that using worksheets makes students more active and the learning process more interesting.

CONCLUSION

Based on the research and development that has been carried out and the conclusions obtained, namely producing products in the form of computationally integrated student worksheets assisted by mobile MatLab in the Matrix Algebra course through a development process using the Multimedia Development Life Cycle (MDLC) model consisting of concept, design, material collection, manufacture, testing, and distribution stages, student worksheets that have been developed are included in the level of validity as very valid, and student worksheets that have been developed have a very practical level of practicality.

A limitation of this research is that it assesses only the validity and practicality of the product, not its effectiveness. This research implies that, given the product's very valid and practical results, further research can be carried out to test its effectiveness, and it can then be widely used in learning.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

SD developed student worksheets. FU developed the MatLab mobile program. R designed student worksheets and created a video on the use of MatLab mobile.

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