

Development of Worksheet to Improve Learning Independence

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ABSTRACT

The purpose of this research is to produce a product of worksheet on differential orde materials for measuring increased self-reliance learning from before using a worksheet and after using a worksheet. Research and Development, the methods used in this research are the three stages of Define, Design, Develop, and Disseminate. This worksheet is validated by four people, two materials experts, and two media experts. Moreover, 2020's four-year academic math student is involved. The result of this worksheet is assessed by material experts 70.46 in the "feasible" category and media experts 87.01 in the "highly feasible" category. Self-reliance is learning increased with results obtained on both previous and post worksheets experiencing a 9.33% increase.

Keywords: Development of Worksheet, Independent learning,

INTRODUCTION

Math is a college that helps students improve and build the ability to solve problems both creatively and independently. Students must have the ability to solve the problem both independently and publicly [1]. Scholars and teachers must apply learning self-reliance to improve skills on student learning on their own [2]. Lack of self-reliance in learning can result in a lack of learning motivation, learning results, and value in the community [3].

Self-reliance is a state and an attitude where one can stand alone and set the matter order without relying on the help of others. The purpose of self-reliance learning are (1) the student's desire to increase knowledge and skill, (2) A desire to look after yourself, (3) a passion for commitment to duty [4]. Self-reliance learning is a thought, feeling, and action that result according to the plan and purpose that a person wants to achieve within himself. self-reliance embalming may depend on the activity of many aspects of the applied phase [5]. The phase-in designing self-reliance is not only free to learn but helpful to think in composing a learning design, choosing a strategy, and purpose in learning [6].

Learning self-reliance is required for the department of Mathematics Education. It happened at one of those differential equations, in which this subject is a mandatory course studied with a total of three-semester credits. Differential equations are equations that involve derivative of an unknown function [7]. Based on the experience of learning differential equations in the fourth semester, insight ability and the ability to accomplish differential equations independently are essential.

Student skills in understanding the problems of subjects, differential equations are still relatively low [8]. Factor errors in the problem of differential equations in both the inside and the outside factors [9]. The inside factors involving a student forget its self-solution, while the outside factors include a lack of learning tools or media. The issues that occurred suggest that most students are still in the low category in their comprehension ability and think about the completion steps. Apart from the lack of insight ability and the ability to accomplish a task independently that causes low ability to solve differential equations, there is also the problem of the sustainability students use during study. One of the problems that occur in the textbooks is that they lack interactive and do not attract student attention, and thus the students' learning motivation is low [10].

Students still use textbooks that focus exclusively on material presentation only without scenting other sources. At differential equations are still very rare in the teaching materials designed by lectures to facilitate students and build learning self-reliance. Consistent with the fact that a model or learning strategy alone is not sufficient in DSN learning to use appropriate media assistance [11]. One effort educators make is to have expertise and skills in teaching using a worksheet expected to be able to increase student self-reliance [12].

A student's worksheet is a guide to helping students in the learning process of pages with tasks complete. The benefit of the worksheet are (1) students can learn and understand materials according to the given steps, (2) students can practice material concepts that have been studied, (3) add insight and learning tools to be motivated, (4) the learning process becomes more clear, exciting, and enjoyable and then creates a positive attitude during self-study.

RESEARCH METHOD

The research method used Research and Development with the model 4-D presented by Thiagarajan and Semmel. Sugiono said that research methods and development as a scientific way to study, design, produce, and test the validity of the products that have been produced. This is the stage of the research of Define, Design, and Develop. This stage of research is limited to the Development stage. At the defining stage, researchers outline the need to compile a worksheet of analysis. During the design stage, research begin compiling the worksheet by starting a good format from design to writing ordinance at the stage of the worksheet development is validated by material experts and then reading and presentation response to small scale trials. In the result of the initial stage analysis, the worksheet in the trial in the field by measuring the increases responses to self-study students before and after using the worksheet. Validation assessment refers to BSNP 2006. Expert validation scores, group trials, and field trials are assessed and netted on the likert scale and then searched for an average value. As for the rate on the average result of the likert scale results indicated at the following table:

Table 1. Validation Sheet Score Criteria

Interval	Categori
84 – 100	Very Good
68 – 83	Good
52 – 67	Quite Good
36 – 51	Not Good
20 – 35	Very Bad

RESULTS AND DISCUSSION

Product development.

a. Result of Expert Validation

The prototype one is the first product of planning made up of initial analysis, analysis of the students, concept, and purpose analysis. Further, after this is produced prototype one, is validated by both material experts and media experts. The process of validation by assessing the feasibility of the worksheet based on the instrument assessment sheet of the BSNP 2006 with google form format is accompanied by suggestions, comments, and conclusions on the worksheet's worthiness. The result of the validating assessment of the material expert are illustrated in the following pictures:

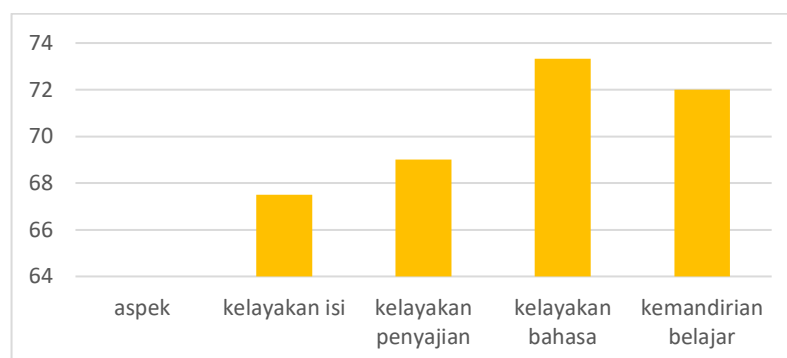


Figure 1. The Validation Assessment of Material Experts

And the result of the validation assessment of media experts are illustrated in this image:

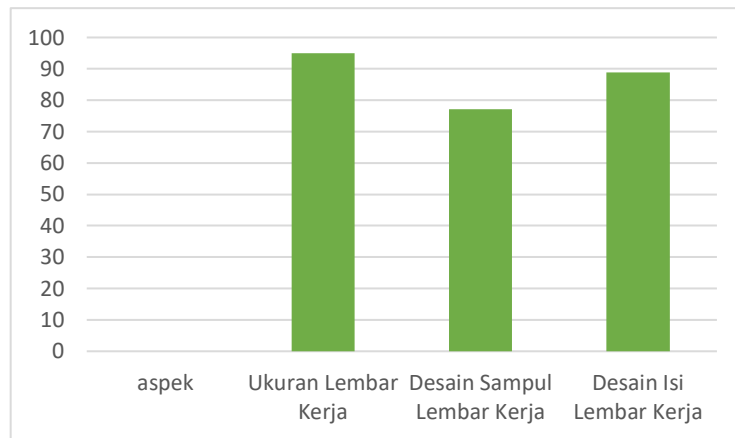


Figure 2. The Validation Assessment of Media Experts

As for the recapitulation of experts validation according to the following chart:

Table 2. The Score of the Expert's Assessment

Experts	Validator 1	Validator 2	Score Average	Criteria
Material Experts	266,78	296,89	70,46	Feasible
Media Experts	280,83	241,43	87,01	Very Feasible

Based on the results of the validation recapitulation in the table, it can be seen that the result of the assessment of the prototype one student worksheet show the result of the material expert's assessment of 70,46 which is included in the "feasible" criteria and for the results of the media expert's assessment of 87.01 which is included in the "very feasible" criteria. As for comments and suggestions were given by experts to improve worksheets, namely adding content to the worksheet, cover illustrations must reflect the content of the material, complete the worksheet answer keys, add some examples and material to the worksheet. Improvements from these suggestions to produce worksheets so that they become the final product.

Initial Prototype	Revised Prototype
<p>Cover prototype one</p>	<p>Cover prototype one align with the material in the worksheet</p>

Example problems on ordinary differential equations and partial differential equations

After the revision, Example problems on ordinary differential equations and partial differential equations

1. PDB (PERSAMAAN DIFERENSIAL BIASA)

Adalah persamaan diferensial yang mengandung hanya satu variabel bebas

Contoh :

- $\frac{dy}{dx} + 2xy = 2x^2 + 1$
- $y'' + 3y' - 2y = e^x$
- $4\frac{\partial^2 y}{\partial x^2}(\sin x) + \frac{\partial^2 y}{\partial x^2} + 5xy = 0$

PDB ini biasa digunakan diaplikasikan pada pemodelan Analisa rangkaian listrik dan pemodelan hukum Newton

2. PDP (PERSAMAAN DIFERENSIAL PARSIAL)

Adalah persamaan diferensial yang mengandung lebih dari satu variabel bebas

Contoh :

- $\frac{\partial y}{\partial x} + 2xy = 2x^2 + 1$
- $y'' + 3y' - 2y = e^x$
- $4\frac{\partial^2 y}{\partial x^2}(\sin x) + \frac{\partial^2 y}{\partial x^2} + 5xy = 0$

Dalam pengaplikasiannya biasa digunakan pada pemodelan persamaan getaran atau gelombang satu dimensi dan pemodelan matematis konduksi panas.

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Contoh :

- $\frac{\partial y}{\partial x} + \frac{\partial y}{\partial t} - 2v = 0$
- $\frac{\partial^2 y}{\partial x^2} - 4\frac{\partial^2 y}{\partial x^2} = 0$
- $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2} = 2xy$

Dalam pengaplikasiannya biasa digunakan pada pemodelan persamaan getaran atau gelombang satu dimensi dan pemodelan matematis konduksi panas.

The placement of additional problems on the basic concepts of differential equations.

SOAL-SOAL TAMBAHAN KONSEP DASAR PERSAMAAN DIFERENSIAL

(No. 1-7) Tentukanlah orde, fungsi yang dicari, dan variabel independen dari PDB berikut

- $y'' - 3xy' = e^{2x}$
- $r^2 \frac{d^2 y}{dr^2} + r \frac{dy}{dr} = r$
- $\frac{d^2 y}{dx^2} + y = x$
- $e^{xy} + xy'' = e^x$
- $y'' - 5y' + 6y = \cos x$
- $\frac{dy}{dx} = 3x$
- $\frac{dy}{dx} + \frac{y}{x} + \frac{dy}{dx} = 0$

(No. 8-14) Selesaikan soal-soal solusi umum dari Persamaan Diferensial yang diberikan

- Tunjukkan apakah $y = e^{2x} - 2$ merupakan solusi dari persamaan diferensial $y'' - 3y = 6$
- Tunjukkan apakah $y = 1 - x^2$ merupakan solusi dari persamaan diferensial $y'' - xy' + y = 0$
- Apakah $y = x$ merupakan solusi dari persamaan diferensial $y'' - xy' + y = 0$
- Dari 3 fungsi yang disediakan berikut ini, fungsi manakah yang merupakan solusi dari persamaan diferensial $x^2 - 4x + e^x = 0$
- Apakah $y = x$ merupakan solusi dari persamaan diferensial $y'' - y = 1$
- Apakah $y = -3t$ adalah solusi dari persamaan diferensial $\frac{dy}{dt} = \frac{t}{2}$
- Carilah solusi umum nilai awal $y(0) = 1, y(1) = 2$

(No. 15-20) Mencari nilai c dari persamaan diferensial yang diberikan

- Carilah nilai c sehingga $y(x) = ce^{2x}, y(0) = 1$
- Carilah nilai c_1 dan c_2 sehingga $y(x) = c_1 x + c_2 + x^2 - 1, y(1) = 1$ dan $y'(1) = 2$
- Carilah nilai c_1 dan c_2 sehingga $y(x) = c_1 \sin x + c_2 \cos x + 1, y(0) = 0$ dan $y'(0) = 0$
- Carilah nilai c_1 dan c_2 sehingga $y(x) = c_1 e^x + c_2 e^{-x}, y(0) = 1$ dan $y'(0) = -1$
- Carilah nilai c_1 dan c_2 sehingga $y(x) = c_1 \sin x + c_2 \cos x, y(0) = 1$ dan $y'(0) = 1$
- Carilah nilai c sehingga $y(x) = ce^{2x}, y(2) = -3$

Change in the placement of additional problems on the basic concepts of differential equations.

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- Carilah nilai c_1 dan c_2 sehingga $y(x) = c_1 \sin x + c_2 \cos x + 1, y(0) = 0$ dan $y'(0) = 0$
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- Carilah nilai c sehingga $y(x) = ce^{2x}, y(2) = -3$

Display fonts in the command section
 (Mahasiswa dapat menyelesaikan dengan cara penyelesaian sesuai dengan langkah penyelesaian kalian masing-masing)

Penyelesaian :

The requirement for a homogeneous differential equation is less complete

- Syarat dapat dikatakan homogen jika $M(x,y)$ dan $N(x,y)$ adalah homogen dan berderajat sama.

Example of homogeneous differential equations only prove that the PD is homogenous

Change the font in the command section in answering questions

(Mahasiswa diminta untuk menyelesaikan soal dengan Langkah penyelesaiannya masing-masing)

Penyelesaian :

Adding one condition to the homogenous differential equation

- Syarat dapat dikatakan homogen jika $M(x,y)$ dan $N(x,y)$ adalah homogen, berderajat sama dan jika dapat dinyatakan dalam bentuk

$$f(x,y) = g\left(\frac{y}{x}\right)$$

Added examples of problems on how to solve homogeneous differential equation

Proceeding books:

The 2nd International Conference of Education on Science, Technology, Engineering, and Mathematics ICE-STEM 2020)

2. Apakah PD $(x^2 - 3y^2)dx + 2xy = 0$ merupakan PD homogen?
 Penyelesaian : $(x^2 - 3y^2)dx + 2xy = 0$

$$\frac{dy}{dx} = -\frac{x^2-3y^2}{2xy}$$

$$\frac{dy}{dx} = \frac{3y^2-x^2}{2xy}$$

$$\frac{dy}{dx} = \frac{3y^2}{2xy} - \frac{x^2}{2xy}$$

$$\frac{dy}{dx} = \frac{3y}{2x} - \frac{x}{2y}$$

$$\frac{dy}{dx} = \frac{3}{2}\left(\frac{y}{x}\right) - \frac{1}{2}\left(\frac{x}{y}\right) \rightarrow \text{Sudah berbentuk } g\left(\frac{y}{x}\right)$$

Mahasiswa
 sial Orde Satu

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2. Apakah PD $(x^2 - 3y^2)dx + 2xy = 0$ merupakan PD homogen?
 Penyelesaian : $(x^2 - 3y^2)dx + 2xy = 0$

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$$\frac{dy}{dx} = \frac{3y^2}{2xy} - \frac{x^2}{2xy}$$

$$\frac{dy}{dx} = \frac{3y}{2x} - \frac{x}{2y}$$

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Mahasiswa
 sial Orde Satu

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∴ maka PD $(x^2 - 3y^2)dx + 2xy = 0$ adalah persamaan diferensial homogen

∴ maka PD $(x^2 - 3y^2)dx + 2xy = 0$ adalah persamaan diferensial homogen

LATIHAN SOAL PERSAMAAN DIFERENSIAL HOMOGEN

1. Selesaikan $(x^2 - 3y^2)dx + 2xy dy = 0$
 Penyelesaian :
 Langkah 1 : Tunjukkan bahwa PD diatas adalah homogen

3. Selesaikan $y' = \frac{x^2+y^2}{xy}$
 Penyelesaian :

Langkah 1: PD diatas adalah homogen, karena persamaan sudah berbentuk $g\left(\frac{y}{x}\right)$

Langkah 2 : Transformasi $y = xv$, maka diperoleh $v = \frac{y}{x}$ dan $y' = v + x\left(\frac{dv}{dx}\right)$

$$y' = \frac{x^2+y^2}{xy}$$

There is only one type of integration factor or non-exact OD in this solution

FAKTOR INTEGRASI ATAU PD NON EKSAK

- Dalam persamaan diferensial bentuk $M(x,y)dx + \mu(x)N(x,y)dy = 0$ yang memenuhi persamaan diferensial eksak, apabila syarat awal persamaan diferensial eksak tidak terpenuhi maka perlu adanya faktor tambahan yaitu factor integrasi
- Apabila PD terbukti bahwa PD tidak eksak jika $\frac{\partial M(x,y)}{\partial y} \neq \frac{\partial N(x,y)}{\partial x}$

Mahasiswa
 sial Orde Satu

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Maka perlu adanya faktor integrasi:

$$\mu(x) = e^{\int p(x)dx}$$

dimana $p(x) = \frac{1}{M(x,y)}\left(\frac{\partial N(x,y)}{\partial x} - \frac{\partial M(x,y)}{\partial y}\right)$

atau $p(x) = \frac{1}{N(x,y)}\left(\frac{\partial M(x,y)}{\partial y} - \frac{\partial N(x,y)}{\partial x}\right)$

sehingga bentuk persamaan berubah menjadi :

$$\mu(x) M(x,y)dx + \mu(x)N(x,y)dy = 0$$

Additions regarding the types of integration factor or non-exact PD that are listed in the table

- Tabel berikut ini adalah beberapa faktor-faktor pengintegrasi yang umum digunakan dan kondisi yang menyertainya

Kelompok suku	Faktor Pengintegrasi $I(x,y)$	Diferensial eksak dengan (x,y)
$y dx - x dy$	$\frac{1}{x^2}$	$\frac{x dy - y dx}{x^2} = d\left(\frac{y}{x}\right)$
$y dx - x dy$	$\frac{1}{y^2}$	$\frac{y dx - x dy}{y^2} = d\left(\frac{x}{y}\right)$
$y dx - x dy$	$\frac{1}{xy}$	$\frac{x dy - y dx}{x^2 + y^2} = d\left(\ln\frac{y}{x}\right)$

Mahasiswa
 sial Orde Satu

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$y dx - x dy$	$\frac{1}{x^2 + y^2}$	$\frac{x dy - y dx}{x^2 + y^2} = d\left(\arctan\frac{y}{x}\right)$
$y dx + x dy$	$\frac{1}{xy}$	$\frac{y dx + x dy}{xy} = d(\ln xy)$
$y dx + x dy$	$\frac{1}{(xy)^n, n > 1}$	$\frac{y dx + x dy}{xy} = d\left[\frac{-1}{(n-1)(xy)^{n-1}}\right]$
$y dy + x dx$	$\frac{1}{x^2 + y^2}$	$\frac{y dy + x dx}{x^2 + y^2} = d\left[\frac{1}{2}\ln(x^2 + y^2)\right]$
$y dy + x dx$	$\frac{1}{(x^2 + y^2)^n, n > 1}$	$\frac{y dy + x dx}{(x^2 + y^2)^n} = d\left[\frac{-1}{2(n-1)(x^2 + y^2)^{n-1}}\right]$

Chapter for exact differential equation and integration factors are combined in one chapter

Separation for exact differential equations chapter and integration factor chapter

**BAB V
 FAKTOR INTEGRASI**

- Secara umum persamaan $M(x,y)dx + N(x,y)dy = 0$ tidak eksak. Fungsi untuk mengubah persamaan diferensial tidak eksak ke dalam bentuk persamaan diferensial eksak adalah faktor integrasi.
- Jenis - jenis faktor integrasi

Terdapat beberapa jenis faktor integrasi, yaitu :

- a. Jika $f(x) = \frac{\partial M}{\partial y} - \frac{\partial N}{\partial x}$, dimana $f(x)$ merupakan fungsi dari x saja.

Faktor integrasinya : $e^{\int f(x)dx}$

**BAB IV
 PERSAMAAN DIFERENSIAL
 EKSAK & FAKTOR INTEGRASI**



PERSAMAAN DIFERENSIAL EKSAK

- Persamaan diferensial eksak merupakan salah satu jenis persamaan diferensial biasa yang sering digunakan dalam ilmu siswa dan Teknik.
- PD Eksak adalah suatu PD tingkat satu dan berpangkat satu yang berbentuk $M(x,y)dx + N(x,y)dy = 0$ jika ada suatu fungsi $f(x,y)$ sehingga $f(x,y) = M(x,y)dx + N(x,y)dy$
- Solusi umum untuk PD eksak orde pertama adalah $f(x,y) = c$

Note : jika $M(x,y)$ dan $N(x,y)$ merupakan fungsi kontinu dan memiliki turunan parsial pertama yang kontinu pada sebuah segiempat bidang xy , maka $M(x,y)dx + N(x,y)dy = 0$ adalah eksak jika $\frac{\partial M(x,y)}{\partial y} = \frac{\partial N(x,y)}{\partial x}$



- Penyelesaian PD Eksak dapat diselesaikan dengan dua acara, yaitu di langkah setelah membuktikan bahwa PD adalah PD eksak maka integralkan $M(x,y)$ terhadap x atau dapat juga dengan mengintegalkan $N(x,y)$ terhadap y .

FAKTOR INTEGRASI ATAU PD NON EKSAK

- Dalam persamaan diferensial bentuk $M(x,y)dx + \mu(x)N(x,y)dy = 0$ yang memenuhi persamaan diferensial eksak, apabila syarat awal persamaan diferensial eksak tidak terpenuhi maka perlu adanya faktor tambahan yaitu factor integrasi

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- Solusi umum untuk PD eksak orde pertama adalah $f(x,y) = c$

The content in this worksheet is still too simple Additions to content on a worksheet (1)

(1)

Ada 2 bentuk pada PD Orde Satu, yaitu :

- Bentuk Implisit
 $F(x,y) = 0$ atau $F(x,y,y') = 0$
- Bentuk Eksplisit
 $\frac{dy}{dx} = f(x,y)$ atau $y' = f(x,y)$

Contoh :

1. $xy' + y^2 + x^2 + 4 = 0$ atau $\frac{dy}{dx} + y^2 + x^2 + 4 = 0$

PD Orde Satu bentuk implisit

2. $y' = 5y + e^{2x}$ atau $\frac{dy}{dx} = 5y + e^{2x}$

PD Orde Satu bentuk eksplisit

Perhatikan letak orde turunan variabel y' terhadap x nya

(2)

Awal : $p(x)dx + q(y)dy = 0$

Integral : $\int p(x)dx + \int q(y)dy = c$,

dimana c adalah konstanta sembarang

Contoh :

Tentukan solusi PD $\frac{1}{x}dx - \frac{1}{y}dy = 0$

Penyelesaian :

$$\int \frac{1}{x} dx = \int \frac{1}{y} dy$$

$$\ln x = \ln y + c$$

$$\ln x - \ln y = c$$

$$\frac{x}{y} = c$$

Inget!!
 Natural Logarithm Rules & Properties

- $\ln(x \cdot y) = \ln(x) + \ln(y)$
- $\ln(x/y) = \ln(x) - \ln(y)$
- $\ln(x^y) = y \cdot \ln(x)$

(3)

Ada 2 bentuk pada PD Orde Satu, yaitu :

- Bentuk Implisit
 $F(x,y) = 0$ atau $F(x,y,y') = 0$
- Bentuk Eksplisit
 $\frac{dy}{dx} = f(x,y)$ atau $y' = f(x,y)$

Inget !

y' atau $\frac{dy}{dx}$ adalah turunan pertama dari y terhadap variable x .
 y'' atau $\frac{d^2y}{dx^2}$ adalah turunan kedua dari y terhadap variable x

Contoh :

1. $xy' + y^2 + x^2 + 4 = 0$ atau $\frac{dy}{dx} + y^2 + x^2 + 4 = 0$

PD Orde Satu bentuk implisit

2. $y' = 5y + e^{2x}$ atau $\frac{dy}{dx} = 5y + e^{2x}$

PD Orde Satu bentuk eksplisit

Perhatikan letak orde turunan variabel y' terhadap x nya

(2)

Pertama-tama dengan menggunakan solusi umum untuk memecahkan persamaan diferensial dan kemudian menerapkan kondisi awal untuk menghitung nilai c .

Contoh :

Tentukan solusi PD $\frac{1}{x}dx - \frac{1}{y}dy = 0$

Variable y dan y' dengan variable x terpisah diantara tanda "="

Penyelesaian :

$$\int \frac{1}{x} dx = \int \frac{1}{y} dy$$

$$\ln x = \ln y + c$$

$$\ln x - \ln y = c$$

$$\frac{x}{y} = c$$

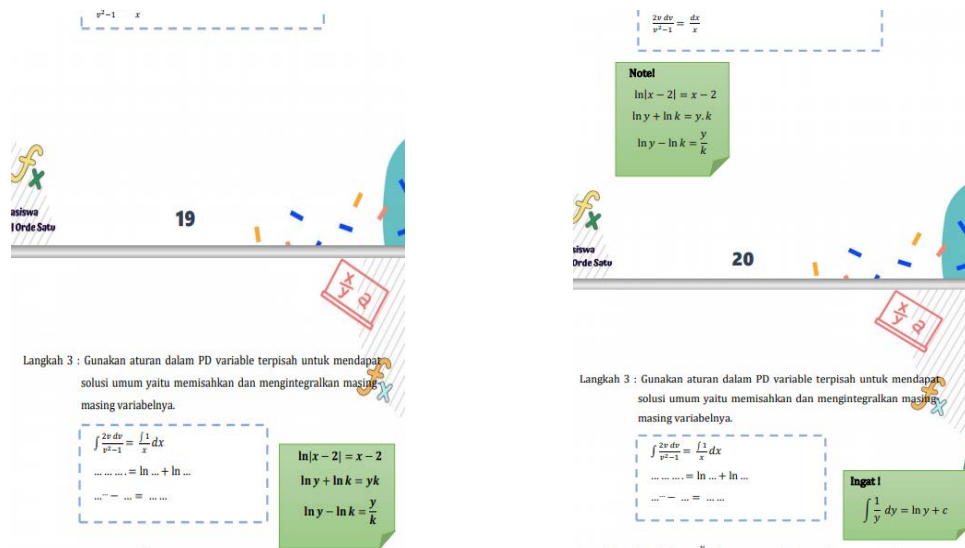
Inget!!
 Natural Logarithm Rules & Properties

- $\ln(x \cdot y) = \ln(x) + \ln(y)$
- $\ln(x/y) = \ln(x) - \ln(y)$
- $\ln(x^y) = y \cdot \ln(x)$

(3)

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b. Limited Trial

Limited trial testing was carried out on 15 UHAMKA mathematics education students in semester IV of the 2019/2020 academic year. This limited test is in the form of student responses to perfecting the worksheet into prototype two which is assessed by indicators of presentation and interest in the worksheet. The responses of 15 students are depicted in the following figure:

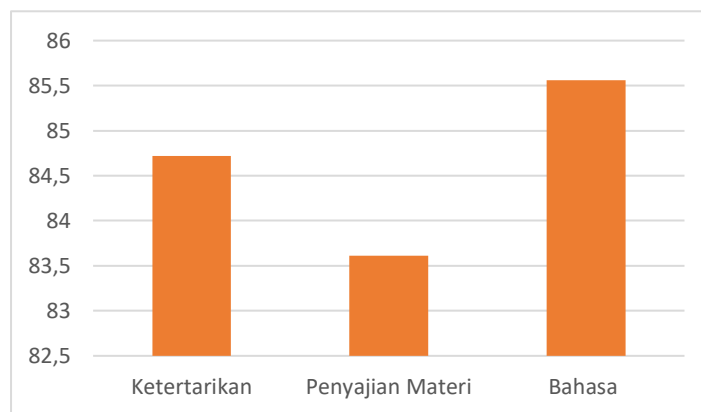


Figure 3. Limited Trial Response Result

Based on the picture above, the average students gave a response of 84.63, which means that the worksheet developed has “good” criteria. The next step is to make repairs before the worksheets are field-tested according to the suggestions given by students to produce prototype three which can be field-tested.

c. Field Trials

Field trials were carried out on UHAMKA Mathematics Education students who occupied the fourth semester of 2019/2020 class IVB with thirty students as respondents. There are two stages in the field trial, namely the student learning independence questionnaire before using the worksheet and the student learning independence questionnaire after using the worksheet. Aspects that become the assessment of the independent learning questionnaire are aspects of self-confidence, aspects of discipline behavior, aspects of having a sense of responsibility, aspects of behaving based on one’s initiative, and aspects of using worksheets. The result of the calculation of the learning independence questionnaire data covering these five aspects from thirty students can be concluded in the following figure:

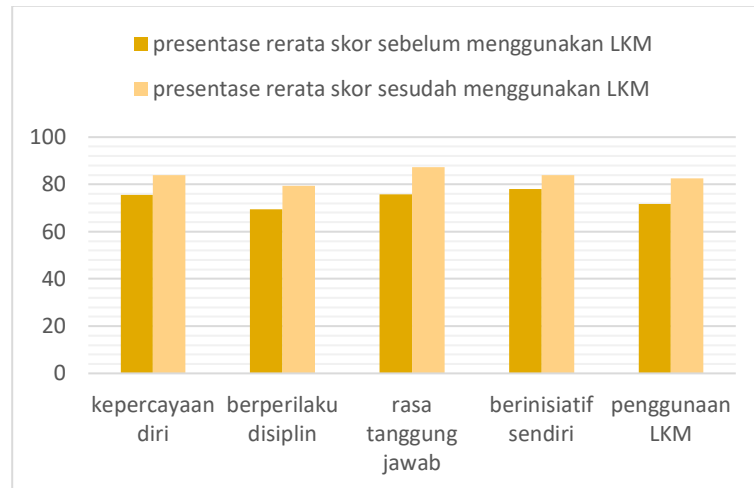


Figure 4. Field Test Response Data Results

In the above picture, the average percentage of each aspect indicates increased self-reliance learned from before and after using a worksheet. The average result is an increase in the overall aspect of 9,33%.

CONCLUSIONS

The research was a Research and Development with a 4-D model and a stage Define, Design, Develop. The result of this study is a worksheet on a one-order differential equations matter that is believed to increase student independence. So that students can learn independently without the teacher's direction first. This is shown on the results of an average self-reliance response study before and after using a worksheet that there is an overall increase in all aspects of learning self-reliance as of 9,33%.

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