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Application of Exponential and Logistic Models in Estimating the Population of Bulukumba Regency in 2020-2030

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ABSTRACT

Population data is useful as planning material in making various policies, including avoiding imbalances between the number of health facilities and services and the population in an area as well as other facilities such as schools, markets, and other public facilities. Ordinary differential equations of exponential and logistic models are used in modeling population dynamics in Bulukumba Regency to obtain population estimates until 2030. The determination of the future population of Bulukumba Regency is based on the growth rate and capacity obtained using the exponential and logistic approaches. The results obtained show that the estimation using the exponential model and the logistic model estimation for 2015-2019 are close to the data from the Central Bureau of Statistics. However, the logistic model is more accurate than the exponential model which is more significantly close to the data from BPS. So that the results of the logistic model are better than the exponential. The logistic model assumes that Bulukumba Regency has a capacity of K = 450000, while the exponential model assumes that the population increases exponentially.

Ordinary Differential Equation; Exponential Equation; Logistic Equation

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1. Introduction

The change in population every year is a form of growth. Population growth can affect the progress and prosperity of an area. Population increase is influenced by birth, death, and migration factors. The population in Bulukumba Regency has increased, therefore it is necessary to estimate the population in the future. Bulukumba Regency is located at the tip of Sulawesi island, precisely in South Sulawesi province. Bulukumba Regency is also famous for its beautiful beach tourism and the local government is also serious in advancing some of its tourism potential (Amin et al., 2022).

Mathematical models have been widely used in problems of disease spread that affect population dynamics in a country, (Hukmah et al., 2023; Madaki et al., 2023, 2020; Sulma et al., 2023), as well as analyzing the relationship between corruption cases and infectious diseases (Radja & Ndii, 2022; Wahid et al., 2023). Some mathematical models that study population growth are exponential and logistic growth models. These models are able to provide an overview of population changes and provide an estimate of the population size in the future.

The use of exponential and logistic growth models has been widely studied in various countries. The exponential growth model assumes that the population growth rate is proportional to the size of the population, if the growth rate is positive then the population will continue to grow exponentially and vice versa. The logistic growth model is the result of the refinement of the exponential model, assuming that at a certain time the population will approach the equilibrium point (Patel & Prajapati, 2016; Ullah et al., 2019; Wei et al., 2015).

In research (Kurniawan et al., 2017) examining the application of logistic differential equations to population growth in the city of Surabaya, it was found that the logistic model was more accurate in predicting population. Prediction of population with a logistic equation using the Adams-Bashforth-Moulton method in West Kalimantan Province in 2021 resulted in a MAPE value of 0.689% with very good criteria (Putri & Noviani, 2022). Based on research (Anggreini, 2020), it is found that with the exponential model the population continues to increase, while the logistic model will not exceed the carrying capacity of 43,997,165. In the research (Anggreini, 2018) it was found that the amount of carrying capacity that limits population growth in Tulungagung is 1,089,103 people with an intrinsic growth rate of $r = 0.07480$ with the estimated population in 2025 is 1.055.578 people.

Mathematical modelling is one way to represent complex problems into mathematical form. Mathematical models can be in the form of equations to represent the problem to be solved (Ndii, 2018).

2. Method

The Exponential Growth Model was introduced in 1798, Thomas Malthus created a basic population growth model known as the exponential growth model (Nuraeni, 2017). If it is assumed that $P(t)$ is a function derived with respect to time, thus a continuous function, then assume that $\frac{dP}{dt}$ expresses the rate of change of population proportional to the existing size. Then $\frac{dP}{dt} = kN$, where k is a proportional constant. In this model it is assumed that the population increases with a population growth rate proportional to the size of the population (Nuraeni, 2017). Suppose $P(t)$ states the population size at time t, and k states the population growth rate then the exponential population model is expressed in the form:

$$\frac{dP}{dt} = kP(t) \tag{1}$$

a special solution is obtained

$$P(t) = P_0 e^{kt} \tag{2}$$

A more realistic growth model is called the Logistic model. This model remains the same as the Maltus growth equation, except that the average growth in this case depends on the size of the population itself expressed in the form of:

$$\frac{dp}{dt} = r\left(1 - \frac{p}{K}\right)p \tag{3}$$

with $K = r/a$. Where r is the intrinsic growth rate and a is a positive constant (Waluya, 2006). The initial motivation for research on this model was that the natural growth model was not appropriate enough for a large enough population and limited space, causing problems due to population density that would reduce the population itself. This logistic population growth model is a refinement of the exponential growth model. In this model, the population size is influenced by the environment such as food supply. The logistic model assumes that at a certain time the population will approach the equilibrium point. At this point the number of births and deaths are considered equal so that the graph is close to constant. The solution of the logistic equation model is obtained by the variable separation method, namely (Boyce & DiPrima, 2009):

$$p = \frac{p_0 K}{p_0 + (K - p_0)e^{-rt}} \quad (4)$$

with

p : Number of population at time t

p_0 : The number of initial population at time $t = 0$

K : Carrying capacity of an area for population

r : Rate of population growth rate

The research method used is quantitative using secondary data obtained from the Central Statistics Agency of Bulukumba Regency, in the form of quantitative data in the form of numbers. The first stage of the research is to determine the research subject, namely the population of Bulukumba Regency in 2015-2019. The second stage, collecting research data, obtained from secondary data from the Central Statistics Agency of Bulukumba Regency. The third stage is to analyze the data using exponential and logistic models and then determine the carrying capacity (K) and instrinsic growth rate (r) for the logistic model. The fifth stage, comparing the estimation results obtained with the results of the population census of Bulukumba Regency in 2015-2019. The last stage is to calculate the estimated population of Bulukumba Regency in the future from 2020 to 2030.

3. Result and Discussion

To obtain the results of population projections in Bulukumba Regency, first analyze the calculation of the population so that the pattern and amount of data to be used can be known. (Anggreini, 2020). The amount of data used in this study is based on the number of population projections available and accessible at the Central Statistics Agency of Bulukumba Regency. Based on the available data, it was found that the average population of Bulukumba Regency from 2015-2019 was 415.671 people, the highest population in 2019 was 420.603 people, and the lowest population in 2015 was 410.485 people. In Table 1 below, the population of Bulukumba Regency in 2015-2019 is given, which is obtained from data from the Central Statistics Agency of Bulukumba Regency.

Table 1. Total Population of Bulukumba Regency

Year	Total Population P(t)
2015	410.485
2016	413.229
2017	415.713
2018	418.326
2019	420.603

The data in Table 1. was used to calculate the estimated population of Bulukumba Regency with the 2015 population as P_0.

a. Population growth solution with exponential model

Using differential equations $P(t) = P_0 e^{kt}$, where $P_0 = 410.485$. To obtain projections, calculations in previous years were analyzed to see the trend direction of the data used. The value of k was obtained using the population numbers P_0 and $P(1)$ as follows:

$$P(1) = P_0 e^{k}$$

$$413.229 = P_0 e^k \tag{5}$$

for $t = 2$ is obtained

$$415713 = P_0 e^{2k} \tag{6}$$

from equations (5) and (6) obtained $k = 0{,}00599$. Thus the population for each year can be estimated by $P_0 = 410485$

$$P(t) = 410.485\ e^{0{,}00599t}$$

for $t = 3$, is obtained

$$P(3) = 410485\ e^{0{,}00599(3)} = 417.928$$

So, the estimated population of Bulukumba district with the exponential model is given in Table 2 below:

Table 2. Population of Bulukumba Regency with exponential model

Year	Total Population P(t)
2015	410.485
2016	412.951
2017	415.432
2018	417.928
2019	420.438
2020	422.965
2021	425.506
2022	428.062
2023	430.634
2024	433.222
2025	435.824
2026	438.442
2027	441.077
2028	443.727
2029	446.393
2030	449.075

Table 2 shows that the population always increases every year. Based on the exponential model, the population of Bulukumba Regency in 2030 is 449,075 people, meaning that since 2015 there has been an increase in population of 38,590 people. The error value of the estimation results can be calculated using data obtained from Central Statistics Agency of Bulukumba Regency and the estimation results obtained in 2015-2019, with a MAPE (Mean Absolute Percentage Error) value of (Anggreini, 2020):

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\frac{|x_i - F_i|}{x_i} \times 100\% \tag{7}$$

with

n : Amount of data

x_i : Actual data

F_i : Prediction result data

The value generated through the calculation of MAPE, shows the forecasting criteria shown in Table 3.

Table 3. Indicator MAPE Value

MAPE Value	Forecasting Criteria
MAPE<10%	Highly Accurate
10%≤MAPE≤20%	Very Good
21%≤MAPE≤50%	Makes Sense
MAPE>51%	Inaccurate

By using equation (7), the MAPE value for the estimation results using the exponential model is as follows

$$MAPE = \frac{1}{5}\sum_{i=1}^{5}\frac{|x_i - F_i|}{x_i} \times 100\% = 0{,}0538\%$$

Based on the results of the MAPE value obtained, it shows that the forecasting results using the exponential model are included in the highly accurate category.

b. Population growth solution with logistic model

Population estimates using the logistic model are obtained by determining the population growth rate using a value of $p_0 = 410485$, $p(1) = 413.229$ and it is assumed that the capacity $K = 450.000$ so that the value is obtained $r = 0{,}078633387$. This value is substituted into the equation

$$p(t) = \frac{p_0 K}{p_0 + (K - p_0)e^{-rt}}$$

untuk nilai $t = 2$, diperoleh

$$p(2) = \frac{(410485)(45000)}{410485 + (450000 - 410485)e^{-(0{,}078633387)(2)}}$$

$$p(2) = 415.798$$

Thus, the estimation results in Table 4 are obtained for different values of t

Table 4. Population of Bulukumba Regency with logistic model

Year	Total Population P(t)
2015	410.485
2016	413.229
2017	415.798
2018	418.202
2019	420.449
2020	422.547
2021	424..505
2022	424..332
2023	428.034
2024	429.620
2025	431.097
2026	432.470

2027	433.748
2028	434.936
2029	436.039
2030	437.065

The calculation results in Table 4 are based on the values of $p_0 = 410.485$, $K = 450.000$, and $r = 0{,}078633387$ shows that the population is always increasing every year. In 2030 the population reached 437.065 people, meaning that since 2015 there has been an increase in population of 26.580 people. It can be seen that the total population increase using the exponential model is greater than the logistic model. This is because the exponential model assumes that the population grows under ideal conditions, without considering that an environment has limited resources. As for the logistic model, it assumes that a logistic factor, namely the carrying capacity of an area for population, is also taken into account. For the logistic model, a MAPE value of 0,0173% was obtained, including in the highly accurate category. The smallest MAPE value is the best value because the percentage error is the smallest, and the smallest value is obtained using the logistic model.

4. Conclusion

Based on the results obtained, it shows that the first-order differential equation using the logistic model and the exponential model in estimating the rate of change in population in Bulukumba Regency provides results that are quite close to the data from the Central Statistics Agency of Bulukumba Regency for 2015-2019. However, the logistic model is more accurate than the exponential model which is more significantly close to the data from BPS. So that the better estimation result for the total population of Bulukumba Regency in 2020-2023 is the estimation result obtained from the logistic model.

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Analysis of Spatial Ability in terms of High Self Efficacy

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ABSTRACT

This research was conducted to find out and describe how students' spatial abilities are viewed from high self efficacy. The type of research used is qualitative with a case study approach. The subjects in the study were students with high questionnaire results from the questionnaire categorization results. The technique of taking subjects is purposive sampling, before choosing the subject the researcher gives self efficacy questionnaire to all students of class VIII Al-Qalam. Furthermore, the questionnaire was categorized, then obtained three subjects with high self efficacy. Researchers collected data with questionnaires, document analysis and interviews. In this study the researcher acts as the main instrument, while the supporting instruments of this study are questionnaires, interviews and documents. The data analysis technique used in this research is by collecting data, reducing data, presenting data, and drawing conclusions. The data validity test used is credibility test, transfebility test, dependability test, and confirmablity test. The results showed that each subject with high self efficacy has different and similar characteristics in answering spatial ability questions. All subjects can fulfill the spatial ability indicators well. So it can be concluded that subjects with high self efficacy are able to fulfill spatial ability indicators and have good spatial abilities.

Keyword: Spatial Ability; Self Efficacy

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1. Introduction

Spatial ability leads to the field of Geometry and is very important for students to master. In learning Mathematics, the things that must be considered are geometry and spatial, so that all students can use visualization and spatial to solve problems within the scope of Mathematics (NCTM, 2000). Based on what is stated by NCTM, it is clear that the ability is very important to be mastered by students. In line with Sherman's (1980) opinion that spatial ability is part of the main factors to influence mathematical ability. In previous research by Hutagulung and Harahap (2018) at SMP Negeri 1 Pinangsori class VIII school, found that spatial ability was low. This is evidenced from the questions given to students with data showing that 92.31% of the total number of students get a spatial ability interview score in the incomplete category, because it does not reach the KKM which is 75 with the average value of students obtained ranging from 20-60. From this it can be seen that spatial ability is still lacking.

This is also in accordance with the research of Faradhila, Sujadi & Kuswardi (2013) found that from the daily tests of junior high school students in grade VIII Geometry space material shows, the results of student answers are less and far from the minimum completeness criteria. This is due to the lack of students' ability to imagine images in visual form, causing low student achievement in mathematics. From this, it is concluded that students' ability is still lacking in converting a picture into a real form.

Researchers have conducted preliminary studies with interviews and observations. The interview was conducted with one of the Mathematics teachers at SMPIT Ulul Albab, from the results of the interview obtained information that students' Mathematics ability to solve problems was still low. Students' enthusiasm and motivation in learning Mathematics

decreased due to online learning during the Covid 19 pandemic. This can be seen from students' mistakes when asked to solve math problems. Students still understand better the example problems explained by the teacher but do not understand the concept first so that students cannot understand the meaning of the given problem. In addition, the teacher added that in solving Mathematics problems, students tend to give up when they are unable to work on a problem so that students look at their friends' answers or cheat on their friends' work.

The researcher made observations in the classroom during Mathematics learning, and saw that students tended to ask for answers and ask their friends if they were unable to answer the questions. This can be caused by students' lack of confidence. In addition to the need for spatial abilities in learning geometry, one of the other important things is the attitude of students in learning mathematics, namely self efficacy (Hidayah, Johar & Ikhsan, 2016). Self-efficacy has a close relationship with spatial ability so that it can foster a positive attitude in solving Mathematics problems related to Geometry. Self efficacy can affect a person's ability to complete spatial tasks, and vice versa, spatial ability can affect a person's level of self efficacy. This is in accordance with the research of Ing, Chen, & Sun (2018) which explains that the level of self efficacy in spatial tasks is associated with actual spatial ability, and the significant role of self efficacy in improving spatial ability. Lin and Petersen (1985) in their study showed that students who have high self efficacy are better when completing tasks involving spatial problem solving. Furthermore, Bandura and Newcombe (1983) stated that good spatial ability can increase a person's confidence in his ability to complete mathematical tasks in this case involving space and shape. So it can be concluded that spatial ability and also self efficacy have a positive relationship and can affect the ability to learn mathematics and student achievement.

The positive relationship between self-efficacy and spatial ability will make students able to master Geometry material. The Self efficacy itself according to Bandura (1997), is an individual's belief in his ability to carry out activities or actions to achieve a predetermined goal. Bandura and Locke (2003) state that self-efficacy shows that the level of student confidence in their ability to solve various mathematical problems is getting better. This spatial ability is important especially for learning Geometry, but it is also important for the development of scientific and technological progress. Many previous researchers conducted research with different focuses. In this study, researchers want to examine spatial ability by reviewing from different perspectives, which may be a factor in the lack of student ability in learning geometry. One of the factors in question is self efficacy. Therefore, researchers are interested in analyzing students' spatial abilities in terms of self efficacy.

2. Method

This research uses a qualitative method using a case study approach. The research subjects in this study were students with high self efficacy based on questionnaire categorization. Before selecting the subject, the researcher distributed a questionnaire in the form of a self efficacy statement to all VIII Al-Qalam class students totaling 22 students. Furthermore, the questionnaire results were categorized and selected subjects with high questionnaire results. Based on the results of the questionnaire categorization, only 3 students with high questionnaire categorization results so that the researcher immediately took the subject as a research subject. JS, AAR, & PPC are students who have a high level of self-

efficacy category. Of the three students, they will be given a spatial ability test The following is a list of names of research subjects with high questionnaire results.

Table 1. Subject Code Self Efficacy

Subject Code	Category
JS	High
AAR	High
PPC	High

In this study the researcher as the main instrument and supporting instruments are questionnaires, interviews and documentation. The data analysis technique used is the data analysis technique according to Miles and Huberman (1984) containing data collection, data reduction, data presentation, and conclusion drawing. The data collected in this study in the form of interviews of students' spatial abilities and self efficacy, after the data is obtained then the researcher sorting the data or data reduction, the researcher sorts out the necessary data and discards those that are not needed After being reduced, the data is presented in the form of a description of students' spatial abilities and self efficacy and conclusions are drawn regarding spatial abilities in terms of high self efficacy.

3. Result and Discussion

Self efficacy

Based on the results of the questionnaire related to self efficacy statements, subjects with high categorization results chose positive statements that lead to high self efficacy abilities in accordance with self efficacy indicators. Researchers conducted unstructured interviews with students regarding their answers based on the questionnaire. The researcher asked each subject about how the subject's confidence when in class, and how when the subject gets a difficult problem, does he answer or avoid it. Each subject answered confidently, subject S1 said that he was a person who really believed in himself and always did tasks or demands both difficult and easy independently. Subject S2 answered that he was sometimes confident, but when answering questions he always answered according to his ability and believed in his abilities. While subject S3 answered that he always did the task independently according to his ability when he could not do it he would ask the teacher and ask for an explanation from the teacher.

From the results of the description above, it is found that students with high questionnaire results are students with high self efficacy, namely students who are able to fulfill every aspect of self efficacy. Students who have high self efficacy are also able to answer the spatial ability interview well. This is supported by the opinion of Bandura (2003) who says that students with high self efficacy have stronger motivation, feel more able to overcome obstacles, and dare to take risks in learning. Based on the same source, Bandura (2003) says that students with high self efficacy have a strong belief in their ability to succeed and succeed in various tasks and situations. They believe that the efforts they make will produce positive results and that they have control over their success or failure. In addition, Fitriani (2017) argues that high self-efficacy students will be able to motivate themselves in learning so that their learning outcomes will be satisfactory. Sunaryo (2017) added that high self efficacy will

encourage students' mathematics achievement to be better.

Spatial Visualization

Spatial visualization or spatial visualization is the ability of students to interpret what is in their minds into a real form. The following are the answers from subject S1, subject S2, and Subject S3 on statements related to spatial visualization indicators

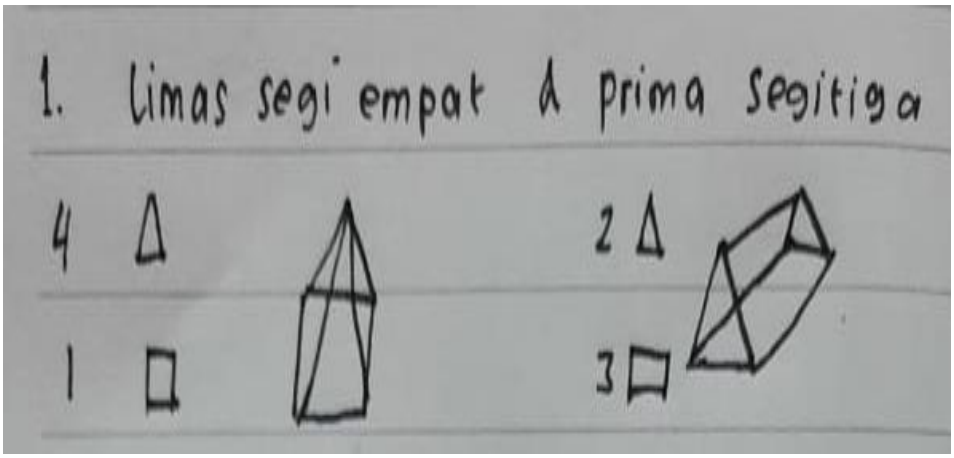

Figure 1. S1 subject's answer spatial visualization

Based on the answers of subject S1, it is obtained that subject S1 is able to answer the questions properly and correctly subject S1 is able to describe the spatial building of several flat shapes that are combined. So it can be assumed that subject S1 has good visualization. Based on the results of subject S2's answers to questions related to spatial visualization, subject S2 was able to answer correctly and was able to describe the building space well. From the results of the interview, subject S2 was able to explain his process in answering the question well. The following are the results of subject S2's answers to spatial visualization questions.

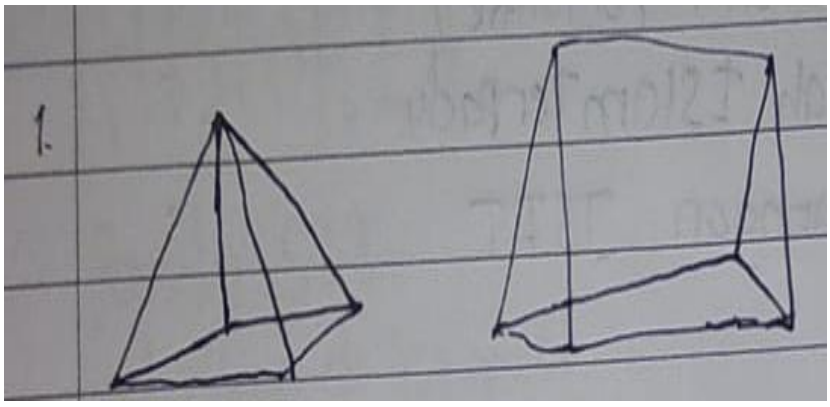

Figure 2. S2 subject's answer spatial visualization

Based on the results of Subject S3's answers, Subject S3 is able to describe the shape of the space from the combined results of several flat shapes as shown in the figure, although the subject S3 is only able to describe 1 space, but it can be assumed that subject S3 has visualization skills because it is able to interpret its imagination into real form. Based on the

interview excerpt of subject S3 explained S3 answered because that's all he got then he described. The answer of subject S3 can be seen in the following figure.

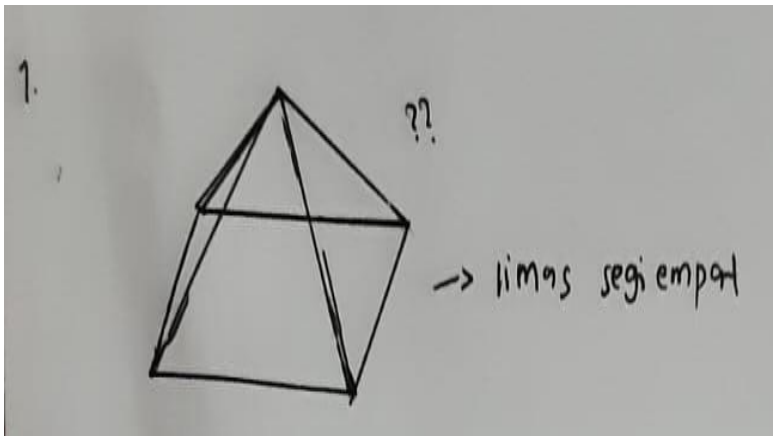

Figure 3. S3 subject's answer spatial visualization

Spatial Orientation

Spatial orientation atau orientasi spasial adalah kemampuan untuk memahami penampilan objek dari arah atau perspektif yang berbeda. Berikut adalah jawaban dari semua subjek dari pertanyaan spasial orientasi.

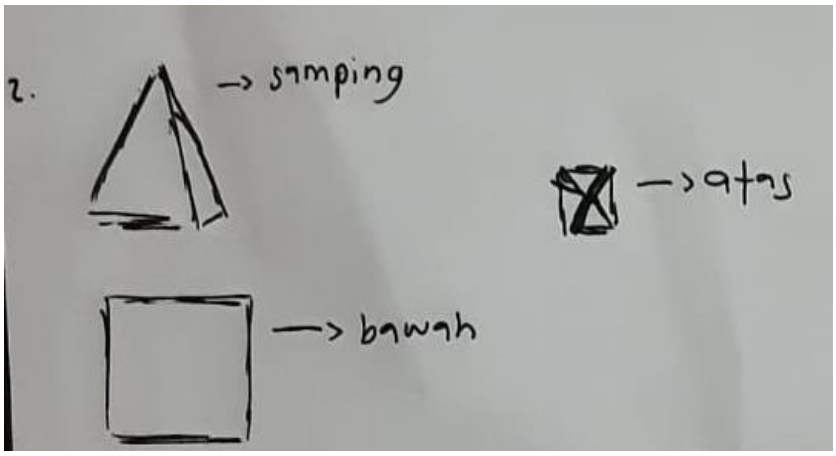

Figure 1. S1 subject's answer *spatial orientation*

Based on the answers above, subject S1 seems to be able to determine the appearance of objects from different points of view or different perspectives, from the subject S1's answer it can be seen that he describes the appearance of the object from the side is a triangle, from below a square and from above is a rectangular pyramid. from this it can be assumed that subject S1 has good spatial orientation skills, from the results of the interview also subject S1 is able to explain how the process answers the question.

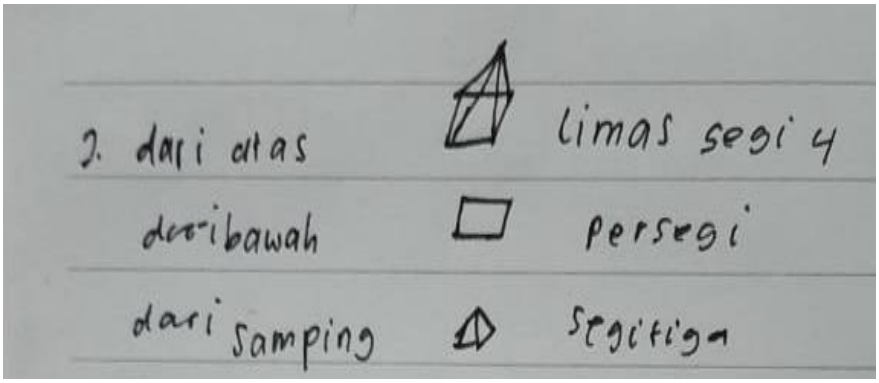

Figure 5. S2 subject's answer *spatial orientation*

The picture above is the answer of subject S2 related to spatial orientation questions, it can be seen that subject S2 was able to answer well. Subject S2 is able to determine the appearance of objects and describe the shape of objects from various points of view. From the results of the interview, subject S2 was also able to explain the shape of each object he drew from various points of view. The following are the results of subject S3's answers to spatial orientation questions.

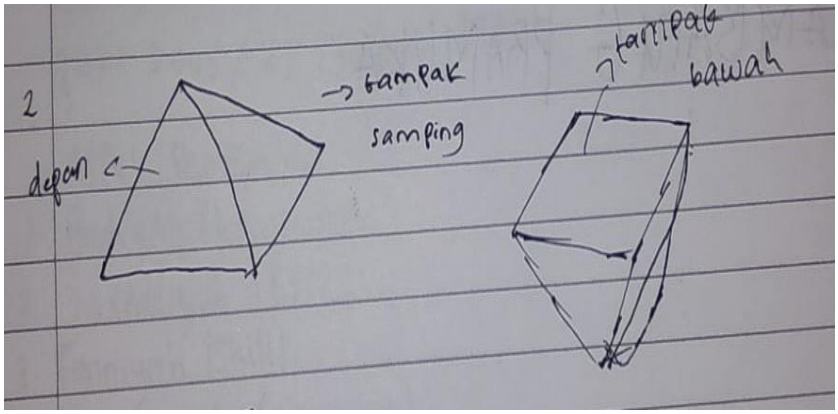

Figure 6. S3 subject's answer *spatial orientation*

Based on the results of subject S3's answers on the spatial orientation indicator, subject S3 can describe the appearance of objects from various points of view as seen in the picture. Subject S3 describes the appearance of the object from the side in the form of a triangle, from below in the form of a rectangle and from above shaped like a pyramid. Although subject S3 does not describe the appearance of the object from the front. But from the results of the description it can be assumed that the subject S3 is able to know the appearance of objects from various points of view.

Spatial Relation

Spatial relation is the ability to understand the relationship of an object with other objects and the ability to understand the position or location of an object after rotating its shape. The following will present the answers of subject S1, subject S2 and subject S3 related to

spatial relations. subject S1 is AAR as the first respondent, subject S2 is JS as the second respondent and subject S3 is PPC as the third respondent who was selected based on the results of the questionnaire.

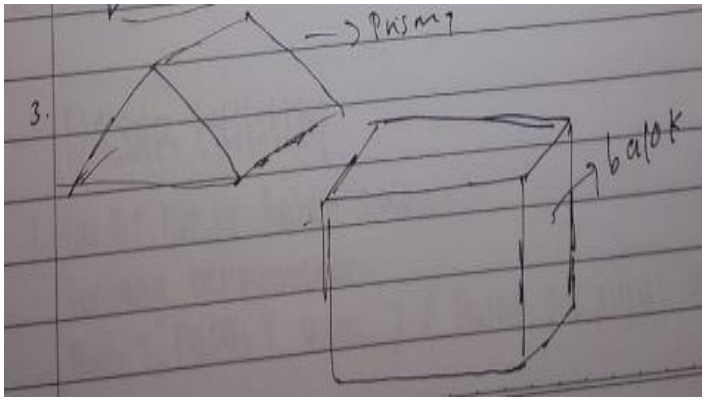

Figure 7. S1 subject's answer spatial relation

Based on the results of subject S1's answers, it can be seen that subject S1 describes prisms, blocks and cubes. From this it can be assumed that subject S1 is able to understand the relationship of an object with others, from the question asked to determine the spatial shapes that can be combined and form a miniature house. Subject S1 was able to understand the question and answer the question well.

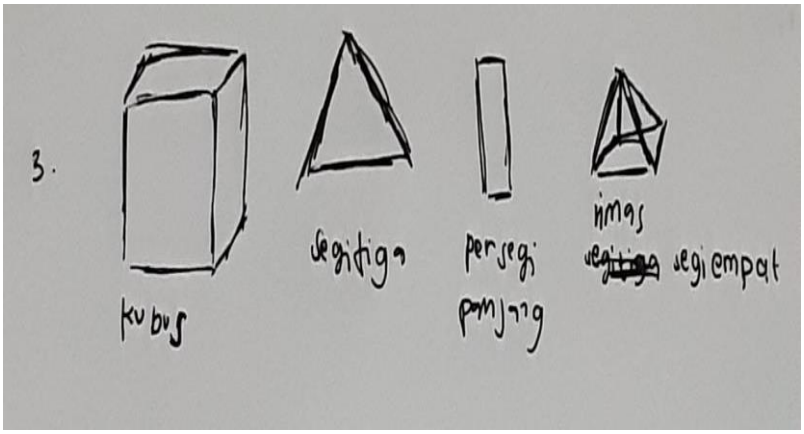

Figure 8. S2 subject's answer spatial relation

The picture above is the answer of subject S2 from questions related to spatial relations based on these answers, it can be seen that subject S2 is able to describe the shapes that can be formed into a miniature house, although the pyramid and beam drawings described by subject S2 do not follow geometric rules, where the shape described by subject S2 is less than perfect, but subject S2 is able to imagine and connect these objects in order to form a miniature house. From the results of the interview, subject S2 explained that the buildings that can form a miniature house are prisms and beams. Subject S2 also explained which part of the miniature house the building was located in. The following are the results of subject S3's answers to spatial relation questions.

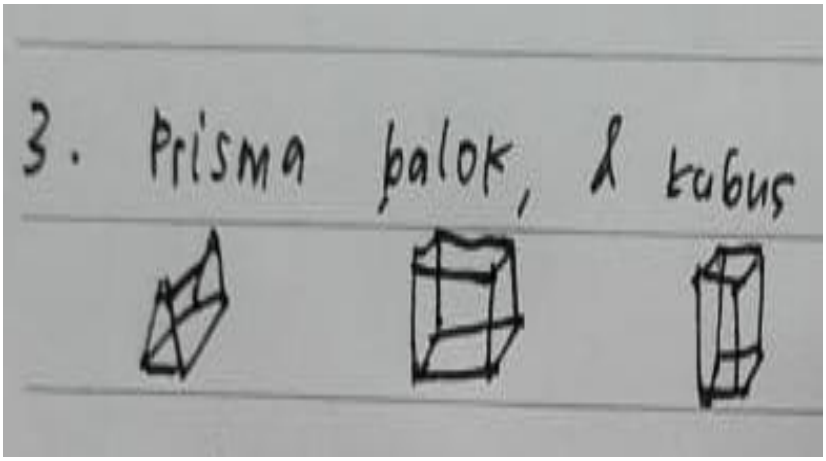

Figure 9. S3 subject's answer spatial relation

Based on the results of the answers of subject S3 related to spatial relation indicators. Subject S3 is able to describe the shapes that can form a miniature house, but subject S3 is wrong in describing the space and flat shapes that can form a miniature house. From the results of the interview excerpt, subject S3 was able to explain which part of the miniature house he described. Subject S3 explained he combined the space and flat buildings, because there is a flat building in the miniature picture of the house.

Based on the results of the research and the results of the answers of all subjects related to spatial visualization, it is found that all subjects have good visualization, there are similarities from the subjects in answering question 1, namely in imagining and combining several flat building objects into a space, but there are also differences from each subject in answering the question. Where subject S1 in answering directly describes according to the question, subject S2 answers by imagining first, while subject S3 is able to imagine and describe but only 1 that he can describe. From this it can be seen that all subjects can meet the indicators of spatial visualization and have the characteristics of students with good visualization. This is in accordance with research conducted by Hasanah (2021) that students with good visuals are able to visualize things in their minds and then convert them into real form well. Students with a visual learning style use the sense of sight more, which means that vision can be realized by seeing or imagining activities as a conceptual depiction in processing information. Based on the results of the research, namely the answers and interview results related to spatial orientation, it is obtained that all subjects are seen that there are similarities from each subject in answering questions related to spatial orientation, namely all subjects are able to describe and determine the appearance of objects from different points of view. Subjects can also imagine real objects that are shaped like a space.

In addition to the similarity, there are also differences from the three subjects, namely in the process of answering questions related to spatial orientation. From this it can be seen that all subjects have good spatial orientation abilities. As stated by Teapon and kusumah (2023) that students who have spatial orientation abilities will easily understand the concept of relative directions such as front, back, left and right. Students are also able to recognize the location of different objects and places. In addition, another opinion, namely according to Lohman (1996),

says that students who have good spatial orientation skills usually have the ability to visualize the appearance of objects in space and are able to determine the appearance of objects from various points of view.

Based on the results of the research, namely the answers and interview results related to spatial orientation, it is obtained that all subjects are seen that there are similarities from each subject in answering questions related to spatial orientation, namely all subjects are able to describe and determine the appearance of objects from different points of view. Subjects can also imagine real objects that are shaped like a space. In addition to the similarity, there are also differences from the three subjects, namely in the process of answering questions related to spatial orientation. From this it can be seen that all subjects have good spatial orientation abilities. As stated by Teapon and Kusumah (2023) that students who have spatial orientation abilities will easily understand the concept of relative directions such as front, back, left and right. Students are also able to recognize the location of different objects and places. In addition, another opinion, namely according to Lohman (1996), says that students who have good spatial orientation skills usually have the ability to visualize the appearance of objects in space and are able to determine the appearance of objects from various points of view.

Based on the results of research findings obtained that there are differences and similarities in each subject with high self efficacy in answering spatial ability questions. The difference between each subject is the difference in characteristics in answering spatial ability questions and the similarity of each subject is from the subject's answer on each indicator. In the spatial visualization indicator, all subjects were able to describe the spatial structure in their minds into a real form, in the spatial orientation indicator, all subjects were able to determine the appearance of objects viewed from different points of view. In the spatial relation indicator, all subjects were able to determine the relationship of an object with other objects and were able to determine the position of the object after rotating its shape. All subjects with high self efficacy are able to fulfill the spatial ability indicators and have good spatial abilities, and among the three subjects with good spatial abilities. The subject who has the best spatial ability among the three subjects is subject S2, this is obtained from the way subject S2 answers spatial ability questions, Subject S2 is able to fulfill all indicators of spatial ability. In imagining or visualizing the shape of the 3-dimensional space object in his mind into a real form, subject S2 is better when compared to subject S1 and subject S3. In addition, it is also seen from the high self-efficacy of subject S2.

Spatial ability is necessary for success in any subject, one of which is geomancy. Students who have spatial abilities will have various positive impacts in their education and development (Istifarida, 2017). Students' spatial abilities will be more improved, especially in terms of problem solving if students have high self-efficacy. Alfurofika (2013) said in her research that students with high self efficacy ability increased mathematical problem solving ability. Thus, self efficacy can have a significant impact on one's spatial ability, and conversely, improved spatial ability can also help build higher self-efficacy. Therefore, developing self-efficacy in spatial ability can help individuals achieve better in various tasks involving spatial aspects.

4. Conclusion

Based on the research findings, differences and similarities were obtained from each student with high self efficacy in answering spatial ability questions, but all subjects with high self efficacy were able to answer spatial ability questions and fulfill spatial indicators well. So it can be concluded that all subjects with high self efficacy have good spatial abilities. The suggestion from this research for future researchers is to dig deeper into students' spatial abilities in learning mathematics so that a good learning design can be prepared

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Differentiated Learning Approaches in Introvert and Extrovert Students from The Aspect of Personality Type in Vocational School Students

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ABSTRACT

The main objective of this research is to obtain data related to differentiated learning for introverted and extroverted students in vocational education/Vocational High Schools (SMK). The research carried out is a type of qualitative research with a case study approach. The data collection techniques used in this research were interviews and documentation. The questions will develop and be more open but still have the same focus. The interviews conducted in this research included interviews with 4 students as subjects chosen by students in class X of SMK Negeri 3 Tarakan. There were 4 participants in this research, namely 2 introverted students and 2 extroverted students, based on the considerations of guidance and counseling educators. The documentation used in this research is field note documents from guidance and counseling teachers as well as reports on the results of observations of the learning process. The Miles and Huberman model analyzes data with data reduction, data display, and conclusion drawing/verification analysis steps. The results of differentiated learning research must be adjusted to students' learning needs, especially students with introverted and extroverted personalities. Good activities and responsibilities can be used to design differentiated learning with a process and content approach. The product approach can also be used for students with introverted and extroverted personalities from the aspect of expressiveness. Meanwhile, the environmental approach can be applied to students with introverted and extroverted personalities by mapping the comfortable environment when studying and doing assignments individually or in groups. And for further research, we can analyze the implementation of differentiated learning in vocational school students with introverted and extroverted personality types.

Keywords: differentiated learning, introvert, extrovert, Vocational High Schools

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1. Introduction

The independent curriculum has now been widely implemented and implemented in schools, both at the preschool, primary, and secondary school levels. The essence of the independent curriculum is that students are free to determine how they learn with the educational path they choose for themselves. Knowing student characteristics can be used as a guide in developing and planning the learning process (Ilham, 2022). The emphasis in the learning process is on learning that facilitates differences in student characteristics/individuals as well as meaningful learning that provides learning experiences according to the needs of different students. With differentiated learning, students can learn according to their respective potential, interests, and abilities, thereby increasing motivation in the learning process. Differentiated learning facilitates differences in student characteristics, namely different learning preferences, backgrounds, interests, readiness, and learning speeds (Komalasari, 2023). To fulfill learning needs for living in society/skills in an era where competition for science and technology is very tight, quality improvements are being made, because the key to the success of the learning process is the fulfillment of learning needs (Devianti & Sari, 2020).

Schools in the independent curriculum prepare their curriculum based on several things, including considering the characteristics and needs of students or schools. There are many individual characteristics of students in the class with different interests, skills, and ways of learning from each other. So that students with these characteristics can learn and develop optimally, they need educational services that can understand the unique differences between these units, namely by implementing differentiated learning (Evendi et al., 2023). Every individual has their way of thinking, speaking, and acting which creates a unique personality that is different from other people. Understanding each individual is a complicated thing because the habits that shape a person arise from culture and environment that shape a person's character, including introverted and extroverted personalities (Krisanti, 2018).

Students at vocational education/Vocational High Schools are expected to have skills when they graduate, both technical and non-technical skills that can be used/utilized to go straight to work or continue their education to a higher level, even to open their own business. In its application, the independent curriculum implements project-based learning so that students will be free and more motivated to learn and work for vocational school students. So far, vocational school students have acquired their skills by carrying out projects, where students have not yet explored their ideas for being creative and creative. However, with differentiated learning, this does not happen. With differentiated learning, it is hoped that students will not only have the role of operators but also be able to design and program their projects with their thoughts and ideas, where this competency will be useful when they work later. Differentiated learning is an effort to adapt the teaching and learning process in the classroom which aims to meet the learning needs of each student (Pitaloka & Arsanti, 2022).

Elements or approaches in differentiated learning include (1) content, namely what essential/main material students need and want to learn or the conditions in which students will get access to its information. Examples include using reading materials, providing teaching materials in the media, using reading partners, and using small groups; (2) process, namely activities that involve students to understand or master the content/material, because of the many differences in learning styles and choices demonstrated by students, classes must be adjusted to suit different learning needs (Fitriyah & Bisri, 2023); (3) the product is a project objective where students are asked to practice, apply, and expand what they have learned in a particular competency; and (4) the learning environment is the conditions around the school or educational institution (Manggalastawa, 2023). Differentiated learning helps students obtain good learning by producing products according to their interests so that students have sufficient space to demonstrate what they have learned (Rosyida et al., 2022).

Differentiated learning pays attention to differences in individual characteristics of students that emerge, one of which is because there are differences in personality so learning needs are also different. Personality types according to Carl Gustav Jung are extrovert and introvert personality types (Ulwiyah & Djuhan, 2021). Success in education and a person's life in society can be influenced by personality factors. The extrovert personality type directs the individual to the external world, while the introverted personality type directs the individual to the individual's internal and subjective world (Prayitno, 2023). An extrovert personality has behaviour that likes situations that involve lots of people, apart from that he dares to take risks, likes to act reflexively and show emotions, and is even inconsistent in his daily life.

Introverts are often said to be the opposite of extroverts. Introverts behave and interact with few friends, always think about the risks of the actions/ behaviour they will carry out, even talk, prefer to keep their feelings hidden, but are consistent and like to look for ideas (Rosida & Astuti, 2015). An Introvert is the character of someone who has a mentally subjective orientation in living his life, an introverted personality has the characteristics of tending to be calm, likes to be alone, and is reflective about what he does (Rumita et al., 2021). Students with introverted and extroverted personality types have differences in prosocial behaviour which is related when seen with behavioural predictions such as positive feelings, attention, and responsibility towards other people (Kurniawan & Stanislaus, 2016). Intelligence and cognitive intelligence among smart students are often associated with extrovert personalities, namely sociable, quick to express opinions, friendly, creative, and more open (Wahyuni & Mardicko, 2021).

These differences will certainly influence the way of learning and learning interactions in the classroom. With different student personalities, students' ways of learning and thinking will also be different. In implementing differentiated learning, a supportive classroom climate is needed, where every student in the class will be welcomed and feel accepted, everyone respects each other and feels as safe as possible in learning (Pebriyanti, 2023). Therefore, researchers feel that there is a need for research to identify differentiated learning for students with introverted and extroverted personality types in vocational schools from a learning needs analysis.

2. Method

The research carried out is a type of qualitative research with a case study approach as a research process, which has the aim of testing research questions and problems, which are an integral part of the phenomenon and the context in which the phenomenon occurs (Prihatsanti et al., 2018). The reason the researcher chose this approach was because it was felt to be most appropriate in identifying and describing how to approach learning for vocational school students with extroverted and introverted personalities.

The main objective of this research is to obtain data so that the data collection technique cannot be missed. In qualitative research, data collection must be in a natural setting, with primary data sources, and in-depth interviews and documentation. The data collection techniques used in this research were interviews and documentation. Semi-structured interviews were chosen and used in this research as a data collection technique because even though there are guided questions asked, the questions will develop and be more open but still have the same focus. The number of introverted and extroverted students in the teacher's documentation in class X is 8 students, namely 3 introverted female students, 2 introverted male students, and 3 extroverted male students. The interviews conducted in this research included interviews with 4 students as subjects chosen by students in class X of SMK Negeri 3 Tarakan.

The considerations used to select the number of subjects 4 were 2 from introverted students and 2 from extroverted students, based on the considerations of guidance and counseling educators. The documentation used in this research is field note documents from guidance and counseling teachers as well as reports on the results of observations of the

learning process. Only two introverted and extroverted students each looked at gender because the researcher considered these 4 students to be enough to dig up information. The length of interview time for each student is no more than 3 hours due to consideration of student concentration. The researcher used the interview method, so the instrument used was an interview guide. The main tool or instrument for data collection is humans or researchers themselves by observing, asking, listening, requesting, and collecting research data. The Miles and Huberman model is used to analyze data with the analysis steps of data reduction, data display, and conclusion drawing/verification.

3. Result and Discussion

There were 4 participants/subjects in this research, namely 2 students with extroverted personalities and 2 students with introverted personalities, based on the guidance and counselling teacher's considerations. The first step the researcher took was to code the participants as follows:

Table 1. Participant Code

Student Personality	Participant Code
Introvert	I01
	I02
Extrovert	E01
	E02

Aspects of extrovert and introvert personality according to Eysenck and Wilson, namely (1) Activity, (2) Sociability, (3) Risk-taking (4) Impulsiveness, (5) Expressiveness, (6) Reflectiveness, and (7) Responsibility (Kristlyna & Sudagijono, 2020). Semi-structured interviews use the following modified guidelines (Hendarta & Isnayanti, 2021):

Table 2. Interview Guidelines

Aspects	**Indicator**
Activity	Not excited Tired easily Uses a lot of thought
Sociability	Doesn't have a wide circle of friends Likes to be alone Distance yourself from the crowd
Risk Taking	Likes challenges Dare to take risks He pays little attention to the consequences of his behaviour
Impulsiveness	Think before making a decision No rush Easy to change your mind
Expressiveness	Harbors more feelings and finds it difficult to express them
Responsibility	Big responsibility Can be given trust
Reflectiveness	Thinking and introspecting what you want to know

Based on the results of interviews with 4 students, these aspects were obtained

1. Activities

   Introverted student I01 is not enthusiastic about participating in mathematics learning because the teacher gives him a lot of assignments, he also feels tired when participating in mathematics learning and experiences tremors, when doing assignments I01 feels doubtful and lacks confidence in his abilities so he thinks that learning, especially mathematics, has all the difficult formulas. Meanwhile, student I02 stated that sometimes he was not enthusiastic and even lazy and sleepy. Students feel that the assignments given by the teacher are too much, especially if learning mathematics in algebra material, the formulas are considered complicated.

   Extrovert student E01 is enthusiastic when learning and wants to learn more deeply about the learning given by the teacher. E02 students have ups and downs in enthusiasm when participating in learning, if the teacher is considered good then they are enthusiastic and participate in learning.

2. Sociability

   Introverted students I01 and I02 from the interview felt less confident, chose not to socialize, and chose not to have many friends because they were comfortable being alone. These students also feel happy if they do assignments or homework individually because they are more comfortable alone, students I01 and I02 think that if they study in groups they cannot concentrate because their friends are not serious about doing their assignments. Extrovert student E01 prefers lots of friends and likes doing group assignments because he wants to communicate with group friends and exchange opinions. E02 prefers lots of friends and likes doing group assignments because he wants to quickly complete the tasks given, but cannot concentrate because his friends talk too much outside of the task.

3. Risk Taking

   Introverted students I01 and I02 are afraid that if they don't do their assignments, they won't get a grade. Meanwhile, extrovert students E01 and E02 like challenges and dare to take risks if they don't do their assignments even though they don't get a grade.

4. Impulsiveness

   Introverted student I01 is afraid of making mistakes when doing assignments. I02 students think first before deciding because they are afraid, they will make the wrong decision, so they don't rush in submitting assignments if they are given assignments and always re-correct the assignments given before submitting them.

   Extrovert students E01 and E02 sometimes re-correct the assignments given before they are submitted and sometimes are in a hurry so they don't double-check the assignments given and submit them straight away. This student also likes being given mathematical formulas that are quick and easy to understand.

5. Expressiveness

   Introverted student I01 doesn't like being given assignments, let alone doing them on the blackboard because the subject lacks confidence in his abilities. I01 finds it difficult to express his opinions and expressions and has a fluctuating interest in learning. Meanwhile, I02 likes it when he is given assignments to do and is willing to write them on the board because if he doesn't do them, it is difficult to express his opinions and

expressions. Extrovert student E01 likes to express feelings experienced during learning hours. However, E02 never expressed what feelings he experienced during learning hours.

6. Responsibility

   Introverted student I01 is responsible for the tasks given to him. Do the tasks given and do it with close friends only. Meanwhile, I02 is responsible for the tasks given and carries them out if given the trust, the tasks given are done with close friends who want to be serious about studying.

   Extrovert student E01 is responsible for the assignments given and always completes the assignments given by the teacher to get grades. If given a task, do it individually or in groups. E02 is less responsible for the assignments given and completes the assignments given by the teacher to only get a grade. However, E02 can also be trusted because when they are given a task, they always work in groups so that the task can be completed quickly.

7. Reflectiveness

   Introverted students I01 and I02 think about what will happen if they do something, while extroverted students E01 and E02 tend to rarely think about and reflect on what they do.

Approaches to Differentiated Learning

1. Content

   About what essential/main material students need and want to learn or the conditions under which students will get access to information. The content in this research comes from learning where students experience a lack of readiness to learn, a lack of interest in learning because students have difficulty accepting the material, and difficulty in completing assignments given by the teacher because the vocational school still uses the lecture method, thus making students not ready to learn and have no interest in learning. However, these students can still take part in learning with different materials according to each student's abilities, always completing the assignments given by the teacher because students are afraid of not getting grades and are afraid of being punished. This can be seen in the aspects of activity, risk-taking, and responsibility.

2. Process

   Activities that involve students to understand or master the content. It is a student's activity in knowledge, understanding, and skills based on the content to be studied. The learning delivered by the teacher uses the lecture method so that students experience disinterest in learning and experience boredom from studying in class, making students lack enthusiasm in participating in learning. This can be seen in the activity aspect, introverted students do not like physical activity because they prefer to remain silent. self-conscious, not enthusiastic, get tired easily, and uses a lot of thought in carrying out things. On impulsiveness, extroverted students are usually impatient and hasty, making quick decisions without long thought. Therefore, the learning process needs to be modified in such a way that different learning needs can be met properly.

3. Products

   Products is a project objective where students are asked to practice, apply, and expand what they have learned in a particular competency and provides challenge or variety and gives students choices so they can express the desired learning. Based on the results of the interview, teachers must design output/output/products from their learning outcomes

by their knowledge, understanding, and skills. Teachers also need to determine the assessment criteria in the rubric so that students will be assessed and what quality is expected from each aspect that students must fulfill. In expressiveness, introverted students hide their feelings and find it difficult to express their expressions. In contrast to expressiveness, extrovert students find it easier to express their feelings and expressions.

4. Learning environment

   Learning environment is the condition surrounding a school or educational institution. The way introverted students learn when studying is that students prefer to study independently rather than study in groups. If studying in groups, students only want to study with friends who want to be serious about studying and friends who only have the same frequency and prefer to study in the classroom rather than in an open environment. calm makes students more comfortable. Meanwhile, extrovert students are the type of students who prefer studying in groups rather than studying independently and prefer studying in an open environment rather than indoors, an open atmosphere makes students more comfortable.

   In terms of sociability, introverted students do not have a wide circle of friends, do not have many friends, like to be alone, and keep away from crowds. This is due to previous research on the sociability of introverted personalities who do not have many friends, like to be alone, and stay away from crowds. Meanwhile, extrovert personalities have lots of friends and like to hang out with everyone (Prayitno & Ayu, 2018). Meanwhile, the opposite is true for extrovert sociability. Someone who is classified as an extrovert usually really likes traveling and also has a sociable nature, but has difficulty controlling his habits of being angry and aggressive (Istichori et al., 2020). This is in line with the opinion that introverts usually prefer activities that are not interesting and tend to be boring, they prefer their routine activities with the same people (Nisa & Mirawati, 2022).

Tomlinson in his book entitled How to Differentiate Instruction in Mixed-Ability Classroom states that there are three aspects of student learning needs, namely 1) Student readiness to learn (readiness), 2) Student interest, and 3) Student learning profile (Wijiastuti & Fitrotun Nisa, 2022). The meaning of learning readiness is how basic skills and knowledge you currently have, to receive new knowledge and skills that will be given and taught by the teacher. So, before carrying out differentiated learning, the first step is to map learning needs, such as learning readiness to modify the level of difficulty of the material that will be taught if using a content approach for introverted and extroverted personality types seen from the activity and reflectiveness aspects. Regarding students' interest needs, introverts and extroverts also have different interests. Some are interested in studying individually and some are interested in studying in groups. According to Jung, individuals with the extrovert personality type have the characteristic of being more expressive in conveying every emotion they feel, so this makes it easier for people with the extrovert type to express every emotion they feel by establishing communication (Virlia, 2018).

This can be seen if we use a process approach where classroom learning activities occur. Students are expected to be active according to their interests so that learning is more enjoyable and makes them enthusiastic about learning. As seen in the personality activities of introverted

and extroverted students. Extroverted students like challenges and dare to take risks, so teachers must also facilitate this by designing learning that is suitable for these students.

The introvert personality type has great responsibility and can be trusted, while the extrovert personality type cannot be trusted, has a low sense of responsibility, and likes to ignore things. Therefore, educators need to consider approaches in delivering material such as varying material, using learning contracts, providing mini-lessons, presenting material with various learning models, and providing various supporting systems. In line with previous research on students' needs in learning, educators need a learning process with a more enjoyable atmosphere for delivering material (I.F., 2018).

4. Conclusion

Differentiated learning for vocational school students with introverted and extroverted personality types involves considering learning needs in the aspects of learning readiness, student interests, and learning profile or a combination of the three, although it focuses more on the skills domain. For vocational school students with introverted and extroverted personalities, the same content differentiation learning approach can be carried out by providing learning materials with reading materials at various readability levels. Meanwhile, for the process differentiation approach, learning can be carried out using coercion or educational games, grouping by allowing students to work alone or in small groups to complete tasks, and providing a center of interest so that introverted and extroverted students can explore themselves, including expressing their learning needs. From the conclusions of this research, it is hoped that teachers will be able to facilitate the learning needs of students with introverted and extroverted personalities in the differentiated learning process. And for further research, we can analyze the implementation of differentiated learning in vocational school students with introverted and extroverted personality types.

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Cox Extended Regression Method in Survival Analysis; Case Study of Diarrhea Patients

(Metode Regresi Cox Extended Pada Analisis Survival; Studi Kasus Pasien Diare)

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ABSTRACT

The study aims to implement survival analysis at the healing rate of a diarrhea patient using the cox extended regression method and estimate the parameters of the cox extended regression model with variables that affect diarrhoea. The data on this study USES the data of diarrhea patients at the PKM Sendana of Majene Regency 2022. Analysis of variable body temperature and vomiting variables does not meet the assumption of proportiontional hazard, this indicates that variable body temperature and puke variables are time-consuming. The best model of the regression cox extended model is a model based on the akaike information criterion value (AIC) of 500.4363. The factors of body temperature and vomiting, where patients who haven't had a change in body temperature have a probability of healing 2.27 times faster than those who have a temperature change. Whereas diarrhea patients who do not experience vomiting during treatment have a probability of recovery of 2.72 times faster than those who experience vomiting during the treatment

Keywords: *Survival Analysis, Regression Cox Extended, Diarrhea Patients, Fiscal Public Health Center Sendana I.*

ABSTRAK

Penelitian ini bertujuan untuk mengimplementasikan analisis survival pada laju sembuh seorang pasien diare menggunakan metode regresi *Cox extended* dan mengestimasi parameter model regresi *Cox extended* dengan variabel yang berpengaruh terhadap penyakit diare. Data pada penelitian ini menggunakan data pasien diare di Pusat Kesehatan Masyarakat (PKM) Kecamatan Sendana, Kabupaten Majene Tahun 2022. Hasil analisis yang diperoleh variabel suhu badan dan variabel muntah tidak memenuhi asumsi proportional hazard, sehingga variabel suhu badan dan variabel muntah bergantung pada waktu. Model terbaik pada model regresi *Cox extended* ialah model dengan fungsi $g(t) = ln(t)$ berdasarkan nilai *Akaike Information Criterion* (AIC) sebesar 500.4363. Pasien yang tidak mengalami perubahan suhu badan mempunyai probabilitas untuk sembuhan 2,27 kali lebih cepat sembuh dibandingkan pasien yang mengalami perubahan suhu badan. Sedangkan pasien diare yang tidak mengalami muntah selama perawatan mempunyai probabilitas untuk sembuhan 2,72 kali lebih cepat sembuh dibandingkan dengan pasien yang mengalami muntah selama perawatan berlangsung.

Kata Kunci: Analisis Survival, Regresi Cox Extended, Pasien Diare, Pusat Kesehatan Masyarakat Sendana I

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1. Pendahuluan

Statistika yang telah mengalami perkembagan yang sangat pesat dengan menemukan berbagai alat analisis yang dapat di gunakan untuk menganalisis suatu kasus, kejadian/event. Salah satunya penerapan metode statistika yang dapat menganalisis penyakit atau kasus pada kelangsungan hidup ialah analisis *Survival* (Muhajir & Palupi, 2018). Suatu analisis statistika yang khusus digunakan untuk menganalisis data atau kasus yang berhubungan dengan waktu atau lama waktu hingga terjadi suatu peristiwa tertentu ialah analisis *Survival*. Analisis *survival* ini biasanya digunakan dalam bidang Kesehatan (Klienbaum & Klein, 2005). Beberapa model yang dikenal pada analisis ini diantaranya ada regresi logistik biner, model *bayesian mixture survival, random survival forest, multivariate adaptive regression splines* dan regresi *cox* (*cox propotional hazard, cox extended*).

Penggunaan metode untuk menyelidiki data umur, waktu tunggu, atau waktu hingga suatu sesuatu peristiwa tertentu terjadi disebut analisis *survival*. Analisis *survival* dengan model regresi *Cox extended* sering digunakan dalam layanan kesehatan, karena sering adanya ke tidak proporsionalnya antara variabel independen dan fungsi waktu sehingga ada kovariat yang nilainya bergantung pada waktu, karena regresi *Cox extended* ialah regresi yang melibatkan variabel independen yang bergantung pada waktu, sehingga penelitian menggunakan regresi ini akan lebih memudahkan kita untuk meneliti (Rahmawati, 2019). Misalkan pada salah satu penyakit yaitu diare (Azaria & Rayhana, 2016; Rahmawati & Faisal, 2019). Menurut Departemen Pendidikan Nasional (2022), epidemi atau wabah adalah suatu penyakit menular yang menyebar dengan cepat, termasuk diare, yaitu suatu gangguan kesehatan dimana penderitanya mengalami muntah-muntah dan diare lebih dari satu atau dua kali dalam waktu yang singkat (Kemenkes RI, 2023).

Berdasarkan penelitian sebelumnya dengan kasus, Faktor-faktor yang mempengaruhi tingkat kesembuhan pasien diare, disimpulkan bahwa jenis kelamin, usia, muntah, suhu badan dan dehidrasi merupakan faktor yang mempengaruhi tingkat kesembuhan pasien diare (Purnamasaro, 2017). Penelitian ketiga, faktor-faktor yang mempengaruhi kelangsungan hidup pasien gagal ginjal menggunakan pemodelan regresi *Cox extended* menyimpulkan bahwa penggunaan metode *Cox extended* untuk mengetahui ketahanan hidup seorang pasien lebih efektif karena melibatkan waktu di setiap perawatannya (Pusparani, 2020). Berdasarkan penjelasan di atas, penulis tertarik melakukan penelitian mengenai metode regresi *Cox Extended* pada analisis survival, dengan studi kasus pasien diare di pusat kesehatan masyarakat (PKM) Kecamatan Sendana, Kabupaten Majene.

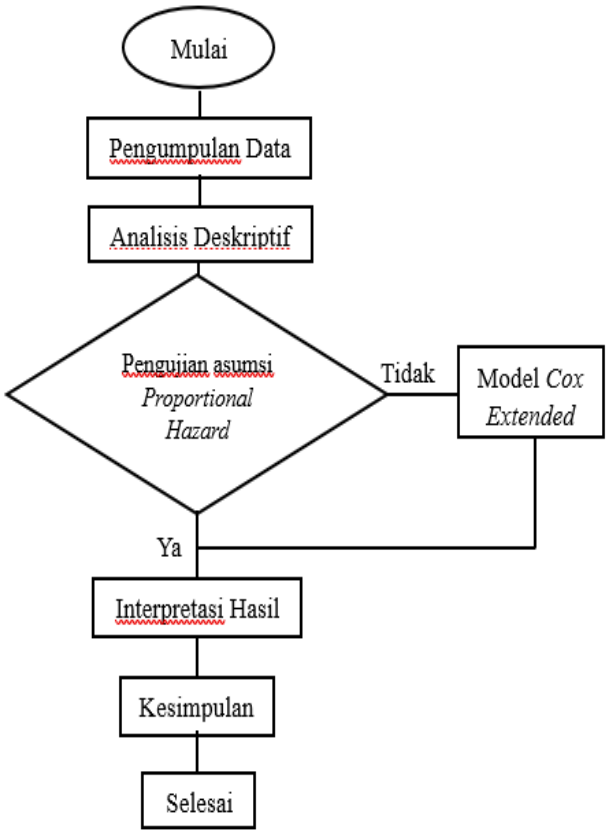
2. Metode

Dalam penelitian ini data yang digunakan adalah data sekunder yaitu data rekam medis pasien diare yang dirawat inap di Pusat Kesehatan Masyarakat (PKM) Sendana 1 Kabupaten Majene. Data sekunder merupakan data yang diolah dan diperoleh dari sumber lain. Data-data tersebut umumnya diperoleh melalui penelitian literatur yang berasal dari buku, majalah, surat kabar, penelitian terdahulu, serta lembaga pemerintah dan instansi swasta. Data keterangan kondisi pasien yang di gunakan terhitung mulai dari bulan Januari 2022 sampai Desember 2022. Skala pengukuran waktu pada penelitian ini menggunakan satuan hari. Data dikumpulkan dari 80 pasien diare, pasien yang telah menjalani rawat inap pada tahun 2022.

Variabel yang digunakan pada penelitian ini adalah variabel *dependen* (respon) dan variabel *independen* (prediktor). Variabel *dependen* pada penelitian ini terdiri dari waktu *survival* (T) pasien dengan penyakit diare hingga mengalami *event* (sembuh) dan untuk status tersensor (d). Sedangkan untuk variabel *independen* dalam penelitian menggunakan variabel yaitu usia, jenis kelamin, dehidrasi, tipe diare, suhu badan, penurunan berat badan, dan muntah.

Metode yang digunakan dalam penelitian ini adalah studi literatur khususnya buku dan jurnal mengenai pokok bahasan regresi *survival* (Lee & Wang, 2023), metode regresi *Cox extended* dan modifikasinya (Maryama, 2016), terutama dalam hal penerapannya dalam analisis data *survival*. Selanjutnya diperoleh persamaan estimasi fungsi *Survival* dari model regresi *Cox extended* (Sanusi et al, 2018). Setelah rumus untuk memperkirakan fungsi *Survival*

diperoleh, maka dilakukan simulasi studi untuk mengidentifikasi faktor-faktor yang mempengaruhi data aktual pada suatu titik waktu tertentu.



Gambar 1. Diagram Alir Kerangka Penelitian.

Tabel 1. Definisi setiap Variabel

Variabel	Definisi	Jenis data
T	Waktu survival (hari) ketika pasien mengidap diare meninggal atau pindah/berhenti atau sembuh dalam waktu periode penelitian berlangsung.	Rasio
d	Pasien dinyatak tersendor atau sembuh (mengalami event)	Nominal
X_1	Pasien yang dirawat memiliki rentang usia.	Nominal
X_2	Pasien yang dirawat berjenis kelamin laki-laki atau perempuan	Nominal
X_3	Pasien mengalami dehidrasi atau tidak selama perawatan	Nominal
X_4	kandungan air *fases* lebih banyak atau *fases* berbentuk setangan cair kandungan air *fases* lebih sedikit.	Nominal
X_5	Pasien mengalami demam atau tidak selama perawatan	Nominal
X_6	Pasien mengalami penurunan berat bada atau tidak selama perawatan	Nominal
X_7	Pasien mengalami muntah atau tidak selama perawatan	Nominal

3. Hasil dan Pembahasan

Penelitian ini menggunakan data seorang pasien penderita penyakit diare. Data tersebut merupakan data 80 pasien yang telah di rawat inap di Pusat Kesehatan Masyarakat (PKM) Sendana 1 pada bulan Januari hingga bulan Desember tahun 2022. Hasil dari penelitian ini, yang akan dibahas ialah mengetahui penerapan metode *Cox Extended* pada analisis *Survival,* estimasi parameter pada model regresi *Cox Extended* dan factor-faktor yang dapat mempengaruhi laju sembuhnya seorang pasien penderita diare. Menentukan hasil metode menggunakan bantuan aplikasi *Software* R.

Uji Asumsi *Proportional Hazard*

Pada penelitian ini menggunakan pengecekan asumsi *proportional hazard* dengan pendekatan *goodness of fit*. Hasil pada uji asumsi *proportional hazard* tersebut dapat dilihat pada penjelasan berikut. Berdasarkan metode pendekatan *goodnes of fit,* terdapat beberapa variabel yang memenuhi dan tidak memenuhi asumsi *proportional hazard*. Hasil untuk uji *goodness of fit* dinyatakan pada Tabel 2.

Tabel 2. Hail Uji *Goodness of Fit*

Variabel	*Chisq*	*p-value*	Keputusan
Usia	0.5917	0.4418	Terima H_0
Jenis Kelamin	3.6002	0.0578	Terima H_0
Dehidrasi	1.4715	0.2251	Terima H_0
Tipe Diare	0.0198	0.8881	Terima H_0
Suhu Badan	7.0721	0.0078	Tolak H_0
Penurunan Berat Badan	0.0510	0.8214	Terima H_0
Muntah	5.1647	0.0230	Tolak H_0

Jika menggunakan nilai α sebesar 0.05, maka menghasilkan keputusan tolak H_0 untuk variabel suhu badan dan muntah. Dengan demikian, dapat disimpulkan untuk variabel suhu badan dan muntah tidak memenuhi asumsi *proporsional hazard* hal ini menunjukkan bahwa penderita diare yang mengalami perubahan suhu badan dan mengalami muntah memiliki probabilitas untuk sembuh dari penyakit diare yang berbeda setiap waktunya.

Pembentukan Model *Cox Extended*

Alternatif sederhana untuk *nonproportional hazar* adalah metode regresi *Cox Extended* dengan *time dependen variabel*. Interaksi waktu yang digunakan adalah fungsi waktu berupa fungsi t, $\ln(t)$, dan *haeviside.* Variabel suhu badan dan muntah merupakan faktor yang diduga mempengaruhi tingkat kesembuhan pada pasien penderita diare yang tidak memenuhi asumsi *proportional hazard*. Oleh karena itu, interaksi dengan mereka perlu dilakukan seiring berjalannya waktu. Penggunaan model *Cox extended* untuk setiap fungsi terhadap waktu dapat dijelaskan sebagai berikut.

1. Model *Cox Extended* dengan $g(t) = t$

Uji asumsi *proportional hazard,* faktor suhu badan dan muntah tidak memenuhi asumsi

proportional hazard , sehingga perlu dilakukan interaksi variabel suhu badan dan muntah dikalikan dengan fungsi waktu $g(t) = t$. Estimasi parameter pada model *Cox Extended* dengan fungsi waktu t dapat dilihat pada Tabel 3.

Tabel 3. Estimasi Parameter Model *Cox Extended* dengan Fungsi $g(t) = t$

Variabel	**Estimasi Parameter**	***Wald Test***	***p-value***
Usia	0.02904	0.013	0.90859
Jenis Kelamin	-0.02447	0.006	0.93825
Dehidrasi	-0.27386	0.689	0.40646
Tipe Diare	-0.12938	0.261	0.61660
Suhu Badan	1.36231	4.986	0.02556
Penurunan berat badan	-0.42882	2.844	0.09169
Muntah	1.53214	6.396	0.01144
Suhu Badan × t	-0.68283	7.780	0.00528
Muntah × t	-0.71019	9.208	0.00241
Likelihood Ratio Test = 28.97			0.000004

Model yang diperoleh dapat dilihat sebagai beriku:

$$\hat{h}(t, \boldsymbol{x}(t)) = \hat{h}_0(t)\, exp(\, 0.02904X_1 - 0.02447X_2 - 0.27386X_3 - 0.12938X_4 + 1.36231X_5 - 0.42882X_6 + 1.53214X_7 - 0.68283(X_5 \times t) - 0.71019(X_7 \times t)).$$

Pengujian serentak pada model dengan penggunan *likelihood rasio test* diperoleh nilai *p-value* 0.000004 . Jika menggunakan $\alpha = 0.05$, maka diperoleh keputusan adalah H_0 ditolak. Dengan demikian, dapat disimpulkan bahwa setidaknya terdapat satu variabel pada model tersebut yang signifikan berpengaruh terhadap *survival* pasien diare di Puskesmas Sendana I.

Pada pengujian parsial menggunakan *wald test*, untuk variabel suhu badan, muntah, (suhu badan × t) dan (Muntah × t) memiliki nilai statistik uji lebih besar dari nilai $X^2_{1,\alpha} = 3.841$ dan *p-value* < 0.05, sehingga hasil keputusannya tolak H_0. Setelah variabel yang tidak signifikan dikeluarkan dari model, estimasi parameter pada model *Cox extended* yaitu variabel yang signifikan dengan interaksi fungsi waktu yang mempengaruhi laju sembuh pasien diare.

Nilai *hazard ratio* dari pasien diare yang mengalami perubahan suhu badan yang berubah-ubah bergantung waktu bisa diketahui dengan menggunakan pemisalan waktu. Pada Tabel 4. menyatakan nilai *hazard ratio* dari penderita diare pada waktu tertentu.

Tabel 4. *Hazard Ratio* Penderita Diare yang Mengalami Perubahan Suhu Badan dengan fungsi $g(t) = t$

Waktu (Hari)	*HR*
1	1.9729
4	0.2544

Tabel 4. menyatakan nilai *hazard rasio* penderita diare yang mengalami perubahan suhu badan. Dapat disimpulkan bahwa semakin lama penderita diare yang mengalami perubahan suhu badan di rawat, semakin kecil probabilitas pasien tersebut cepat sembuh karena penyakit

diare. Misalkan penderita diare mengalami suhu badan normal yang sembuh selama 2 hari, maka penderita tersebut memiliki probabilitas sembuh karena penyakit diare $\frac{1}{0.9967} = 1.003$ kali lebih cepat daripada penderita diare mengalami demam atau suhu badan yang tinggi. Pada pasien yang menderita diare mengalami suhu badan normal yang sembuh selama 4 hari, maka pasien tersebut memiliki probabilitas sembuh dari penyakit diare $\frac{1}{0.2544} = 3.938$ kali lebih cepat daripada pasien yang mengalami demam atau suhu badan yang tinggi.

Nilai *hazard ratio* pada penderita diare yang mengalami muntah-muntah yang berubah seiring berjalannya waktu dapat ditentukan dengan pemisalan waktu. Tabel 5. menunjukkan nilai *hazard ratio* dari pasien diare pada titik waktu tertentu.

Tabel 5. *Hazard Ratio* Penderita Diare yang Mengalami Muntah dengan Fungsi $g(t) = t$

Waktu (Hari)	HR
1	2.2749
4	0.2702

Tabel 5. menunjukkan beberapa nilai *hazard rasio* penderita diare yang mengalami muntah. Dapat disimpulkan bahwa semakin lama penderita diare yang mengalami muntah di rawat, semakin kecil probabilitas pasien tersebut cepat sembuh karena penyakit diare. Misalkan pasien diare tidak mengalami muntah-muntah yang sembuh selama 1 hari, maka penderita tersebut memiliki probabilitas sembuh dari penyakit diare $\frac{1}{1.1182} = 0.894$ kali lebih cepat daripada penderita diare mengalami muntah-muntah. Pada pasien yang menderita diare tidak mengalami muntah-muntah yang sembuh selama 4 hari, maka pasien tersebut memiliki probabilitas sembuh karena penyakit diare $\frac{1}{0.2702} = 3.701$ kali lebih cepat daripada pasien yang mengalami muntah.

Pada penjelasan Tabel 4 dan Tabel 5 peristiwa tersebut dapat terjadi disebabkan oleh berhasilnya perawatan dan pengobatan yang di berikan kepada penderita diare sehingga mempercepat sembuh pasien.

2. Model *Cox Extended* dengan $\boldsymbol{g(t) = ln(t)}$

Selain penggunaan fungsi *t*, variabel yang tidak memenuhi asumsi *proportional hazard* dapat juga diinteraksi dengan fungsi $\boldsymbol{g(t) = ln(t)}$. Estimasi parameter untuk model *Cox Extended* dengan fungsi waktu $\boldsymbol{ln(t)}$ dapat dilihat pada Tabel 6.

Tabel 6. Estimasi Parameter Model *Cox Extended* dengan Fungsi $g(t) = ln(t)$

Variabel	**Estimasi Parameter**	***Wald Test***	***p-value***
Usia	0.02594	0.010	0.91853
Jenis Kelamin	0.01641	0.003	0.95878
Dehidrasi	-0.30234	0.836	0.36053
Tipe Diare	-0.18395	0.506	0.47695
Suhu Badan	0.90293	4.384	0.03628
Penurunan berat badan	-0.40993	2.628	0.10501
Muntah	0.94987	4.878	0.02718
Suhu Badan $\times$ $\ln(t)$	-1.44461	9.429	0.00214

Muntah $\times$ $\ln(t)$	-1.40122	10.109	0.00148
	Likelihood Ratio Test = 29.8		0.00004

Model yang diperoleh ialah sebagai berikut.

$$\hat{h}(t,\boldsymbol{x}(t)) = \hat{h}_0(t)\, exp(\, 0.02594X_1 + 0.01641X_2 - 0.30234X_3 - 0.18395X_4 + 0.90293X_5 - 0.40993X_6 + 0.94987X_7 - 1.44461(X_5 \times ln(\,t)) - 1.40122(X_7 \times ln(\,t))).$$

Menggunakan *likelihood rasio test* pada pengujian serentak terhadap model didapatkan nilai *p-value* 0.00004. Jika nilai α yang digunakan 0,05, untuk keputusan yang dimiliki yaitu tolak H_0 . Dapat dinyatakan bahwa terdapat minimal ada satu variabel pada model yang signifikan mempengaruhi laju sembuh pasien diare di Puskesmas Sendana I.

Berdasarkan pengujian parsial menggunakan *wald test*, untuk variabel suhu badan, muntah (suhu badan $\times$ $\boldsymbol{ln(\,t)}$) dan (Muntah $\times$ $\boldsymbol{ln(\,t)}$) memiliki nilai statistik uji lebih besar dari nilai $X^2_{1,\alpha} = 3.841$dan *p-value* < 0.05, sehingga hasil keputusannya tolak H_0.

Nilai *hazard ratio* pada pasien diare yang mengalami perubahan suhu badan yang berubah seiring berjalannya waktu dapat ditentukan dengan pemisalan waktu. Tabel 7 menunjukkan nilai *hazard ratio* dari penderita diare untuk beberapa waktu tertentu.

Tabel 7. *Hazard Ratio* Pasien Diare yang Memiliki Suhu Badan dengan Fungsi $g(t) = ln(\,t)$

Waktu (Hari)	HR
1	0.5818
4	0.0076

Tabel 7 menunjukkan beberapa nilai *hazard rasio* penderita diare yang mengalami perubahan suhu badan. Dapat disimpulkan bahwa semakin lama penderita diare yang mengalami perubahan suhu badan di rawat, semakin kecil probabilitas pasien tersebut cepat sembuh karena penyakit diare. Misalkan penderita diare mengalami suhu badan normal yang sembuh selama 1 hari, maka penderita tersebut memiliki probabilitas sembuh karena penyakit diare $\frac{1}{0.5818} = 1.7188$ kali lebih cepat daripada penderita diare mengalami demam atau suhu badan yang tinggi. Pada pasien yang menderita diare mengalami suhu badan normal yang sembuh selama 4 hari, maka pasien tersebut memiliki kemungkinan sembuh dari penyakit diare $\frac{1}{0.0018} = 555.5$ kali lebih cepat daripada pasien yang mengalami demam atau suhu badan yang tinggi.

Nilai *hazard ratio* untuk pasien diare yang mengalami muntah yang berubah-ubah di beberapa waktu yang berbeda dapat dilihat menggunakan pemisalan waktu. Tabel 8. menyatakan nilai *hazard ratio* untuk penderita diare di waktu tertentu.

Tabel 8. *Hazard Ratio* Penderita Diare yang Mengalami Muntah dengan Fungsi $g(t) = \ln(t)$

Waktu (Hari)	HR
1	0.6368
5	0.0023

Tabel 8 menunjukkan beberapa nilai *hazard rasio* penderita diare yang mengalami muntah. Dapat disimpulkan bahwa semakin lama penderita diare yang mengalami muntah di rawat, semakin kecil probabilitas pasien tersebut cepat sembuh karena penyakit diare. Misalkan penderita diare tidak menderita muntah-muntah sembuh selama 1 hari, maka penderita tersebut memiliki probabilitas sembuh karena penyakit diare $\frac{1}{0.6368} = 1.5704$ kali lebih cepat daripada penderita diare mengalami muntah. Pada pasien yang menderita diare tidak muntah yang sembuh sewaktu 5 hari, maka pasien tersebut mepunyai probabilitas sembuh dari penyakit diare sebesar $\frac{1}{0.0023} = 434.7827$ kali lebih cepat daripada pasien yang mengalami muntah.

Pada penjelasan **Tabel 7** dan **Tabel 8** kejadian tersebut mampu terjadi karena kesuksesan perawatan dan pengobatan yang di berikan kepada penderita diare sehingga mempercepat sembuh pasien.

3. Model *Cox Extended* dengan Fungsi *Haeviside*

Dapat dinyatakan bahwa ada perbedaan nilai *hazard ratio* sebelum perawatan dan setelah menjalani perawatan hari ke-2, sehingga untuk fungsi *haeviside* yang digunakan yaitu:

$$g_1(t) = \begin{cases} 1, jika\ T \geq 2\ hari \\ 0, jika\ T < 2\ hari \end{cases}$$

$$g_2(t) = \begin{cases} 1, jika\ T < 2\ hari \\ 0, jika\ T \geq 2\ hari \end{cases}$$

Kedua fungsi diatas menyangkut seluruh nilai amatan untuk variabel suhu badan dan variabel muntah. Setelah mengalikan kedua variabel dengan kedua fungsi tersebut, selanjutnya melakukan pengestimasi parameter pada model *cox extended* dengan fungsi *haeviside* dapat dilihat pada Tabel 9.

Tabel 9. Estimasi Parameter Model *Cox Extended* dengan fungsi *Haeviside*

Variabel	**Estimasi Parameter**	***Wald Test***	***p-value***
Usia	0.1414	0.2976	0.5855
Jenis Kelamin	0.3117	0.9930	0.3190
Dehidrasi	-0.1527	0.2152	0.6428
Tipe Diare	-0.3395	1.5499	0.2132
Suhu Badan	-0.6742	3.9159	0.0478
Penurunan Berat Badan	-0.2001	0.6643	0.4150
Muntah	0.5604	0.9796	0.3223
Suhu Badan × $g_1(t)$	1.1881	3.2762	0.0703
Suhu Badan × $g_2(t)$	NA	NA	NA
Muntah × $g_1(t)$	-1.0075	2.5269	0.1119
Muntah × $g_2(t)$	NA	NA	NA
Likelihood Ratio Test = 15,68			0.07

Didapatkan model untuk estimasi parameternya adalah sebagai berikut.

$$\hat{h}(t,\boldsymbol{x}(t)) = \hat{h}_0(t)\, exp(\, 0.1414X_1 + 0.3117X_2 - 0.1527X_3 - 0.3395X_4 - 0.6742X_5 - 0.2001X_6 + 0.5604X_7 + 1.1881(X_5 \times g_1(t)) - 1.0075(X_7 \times g_2(t))).$$

Jika penggunaan nilai $\alpha = 0.05$, sehingga keputusan yang diperoleh adalah H_0 ditolak. Dengan demikian, dapat disimpulkan bahwa minimal terdapat satu variabel dalam model yang signifikan mempengaruhi laju sembuh pasien diare di Puskesmas Sendana I.

Berdasarkan uji parsial menggunakan *wald test,* variabel suhu badan, mempunyai *p-value* kurang dari 0.05, sehingga diperoleh keputusan H_0 ditolak. Dengan demikian dapat disimpulkan bahwa variabel suhu badan berpengaruh signifikan terhadap *survival* laju sembuh penderita penyakit diare di Puskesmas Sendana I.

Dapat dilihat bahwa variabel yang signifikan memiliki pengaruh yang negatif. Hal ini mengakibatkan setiap bertambah satu satuan variabel suhu badan, maka probabilitas pasien akan mengalami *event* semakin kecil. Tabel 10 merupakan nilai *hazard ratio* pada variabel signifikan berpengaruh terhadap laju sembuh pasien diare. Tabel tersebut menyatakan bahwa penderita diare yang tidak mengalami penurunan suhu badan 2 kali lebih mudah sembuh dibandingkan dengan pasien yang mengalami penurunan suhu badan atau demam.

Tabel 10. *Hazard Ratio* Model *Haeviside*

Variabel	HR
Suhu Badan	0.6350

Memilih Model *Cox Extended* Terbaik

Berdasarkan hasil analisis yang dilakukan dengan menggunakan tiga fungsi terhadap waktu, dapat dipilih model terbaik dapat dipilih untuk model *survival* pasien dengan penyakit diare. Pemilihan model terbaik dilakukan dengan membandingkan nilai AIC masing-masing model. Nilai AIC dari masing-masing model.

Tabel 11. Nilai AIC Model *Cox Extended*

Model *Cox Extended*	**Nilai AIC**
$g(t) = t$	550.9821
$g(t) = \ln(t)$	550.4363
Fungsi *Haeviside*	565.8132

Dapat disimpulkan bahwa model *Cox Extended* terbaik yang dapat digunakan untuk memodelkan probabilitas *survival* pasien diare di Puskesmas Sendana I adalah menggunakan fungsi $g(t) = ln(\,t)$ karena model tersebut memiliki nilai AIC terkecil.

4. Kesimpulan

Berdasarkan hasil analisis data pada kasus penyakit diare di Puskesmas Sendana I didapatkan beberapa kesimpulan yaitu transformasi $g(t)$ yang terbaik pada regresi Cox Extended yaitu menggunakan fungsi $g(t) = \ln(t)$. Penentuan estimasi parameter pada regresi *Cox extended* menggunakan uji *likelihood partial* dengan fungsi *Cox extended* diperoleh

$$\hat{h}(t,\boldsymbol{x}(t)) = \hat{h}_0(t)\, exp(\, 0.02594X_1 + 0.01641X_2 - 0.30234X_3 - 0.18395X_4 + 0.90293X_5 - 0.40993X_6 + 0.94987X_7 - 1.44461(X_5 \times ln(\,t)) - 1.40122(X_7 \times ln(\,t))$$

Model regresi *Cox Extended* variabel yang mempengaruhi laju sembuh seorang pasien diare yaitu variabel suhu badan dengan kondisi pasien yang mengalami demam atau tidak selama perawatan dan variabel muntah dengan kondisi pasien mengalami muntah atau tidak selama perawatan. Hal tersebut dapat terjadi karena kesuksesan perawatan dan pengobatan yang di berikan terhadap penderita diare sehingga mempercepat sembuh pasien.

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Technological Pedagogical Content Knowledge on Statistics Material in Junior High School

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ABSTRACT

Learning modules designed based on Technological Pedagogical Content Knowledge (TPACK) are very important to improve the learning experience of students. This research tries to develop a module-based TPACK for statistics in MTs Keppe, Larompong, and Luwu. This study aims to assess the feasibility and effectiveness of statistical learning modules developed based on TPACK. This research is R&D with the ADDIE models. The statistics module was developed based on the needs of junior high school students in Keppe and tested on grade VIII students. The instruments used are expert validation questionnaires practicality questionnaires to assess product feasibility, and learning outcomes tests to assess product effectiveness. The results showed that the TPACK-based statistics module can be feasible to use with validation of 85% by media experts and 87.5% by material experts, with a practicality level of 91%. This module is also effective in improving student learning outcomes with a percentage of 89.5%.

Keyword: Learning Outcomes; Statistics Module; TPACK.

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1. Introduction

Science and technology are two essential things today. A teacher besides having good knowledge must also be able to use technology to support learning activities in the classroom (Arifa et al., 2022). TPACK is a framework that highlights the use of digital technology in learning activities. In TPACK, a teacher is allowed to combine Pedagogic Knowledge (PK), Content Knowledge (CK), and Technological Knowledge (TK) (Hew et al., 2019; Schmid et al., 2021).

The use of TPACK-based learning media encourages students to be active in learning activities because it involves new ways of learning (Wijaya et al., 2020). TPACK can improve (Pramita & Wiranda, 2023) and facilitate students' mathematical problem-solving skills (Putri et al., 2022), as well as increase teachers' creativity towards mathematical literacy (Jamaan & Yerizon, 2023).

Electronic learning modules (e-modules) are modules presented in digital form that already have images, sounds, animations, and videos so they are very helpful in increasing understanding of learning. E-modules are proven to improve students' creative thinking skills (Komarudin, 2022) and understanding of mathematics learning (Ferdianto & Alfiani, 2019).

Initial observations show that there are limitations for teachers in using modules in MTs Keppe. In addition, students have difficulty learning at home due to limited access to textbooks. Therefore, this study tries to design a learning module for Statistics material. Modules are designed based on the needs of students known through the ADDIE stage of this research. Modules are designed in the form of Android-based applications that use a Realistic Mathematics Education (RME) approach. Expert validation and practicality tests are carried out to see the feasibility of the modules that have been designed. After that, an effectiveness

test was carried out to see the level of effectiveness of the module on student statistics learning outcomes.

2. Method

This research is a Research and Development research using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). This research will be conducted in April 2023 at MTs Keppe, Luwu Regency, South Sulawesi. The subject of this study was a grade VIII MTs Keppe student. The instruments used are module validation questionnaires, student response questionnaires, and learning outcomes tests.

The analysis of module validity and practicality is based on the results of tabulations by material experts and learning media experts who each look for percentages using the formula:

$$percentage = \frac{\Sigma Score\ per\ item}{maximum\ score} x100\% \quad (1)$$

These results are then categorized using the following table

Table 1. Product validity categories (Arifa et al., 2022)

%	Category
81 - 100	Very Valid / Very Practical
61 - 80	Valid / Practical
41 - 60	Sufficiently Valid / Sufficiently Practical
21 - 40	Less Valid / Less Practical
0 - 20	Invalid / Impractical

The effectiveness of using modules is known by calculating the completeness of student learning using the following formula

$$\bar{x} = \frac{\Sigma Students\ score}{total\ students} x100\% \quad (2)$$

These results are then categorized using the following table

Table 2. The Category of Minimal Completeness in Mts Keppe

%	Category
90 - 100	Very Good
80 - 89	Good
72 - 79	Enough
61 - 71	Less
0 - 60	Not at All

The e-module developed is declared effective for student statistics learning outcomes if at least 61% of students have a minimum score of 72.

3. Result and Discussion

This R&D research uses ADDIE design. At the *Analysis*, a needs analysis and curriculum analysis are carried out, the results of which can be seen in Table 3.

Table 3. Description of Needs Analysis and Curriculum Analysis

The Analysis	Result	Methode
Needs Analysis	• The ability of students to understand statistical material is still lacking because textbooks are still limited • Textbooks are owned only by teachers, not students. • The LCD projectors are available and but their use is limited, not every meeting • Students do not experience obstacles in using technology • From this, students need modules that can be accessed from anywhere	Interview with teacher on December 29, 2022
Curriculum Analysis	• The curriculum used is curriculum 201 • The core competencies and basic competencies that exist for statistical materials support the use of modules that integrate science and technology	Curriculum Document Analysis

At the *Design*, the findings obtained at the analysis stage are followed up. In this case, the design of statistical material modules that integrate science and technology is carried out. First, the module was designed using *power point 2019*, then converted with *iSpring Suite 9*, and finally used *website 2 Apk Builder* to be converted again into an Android-based application. Navigation structure designed following Figure 1.

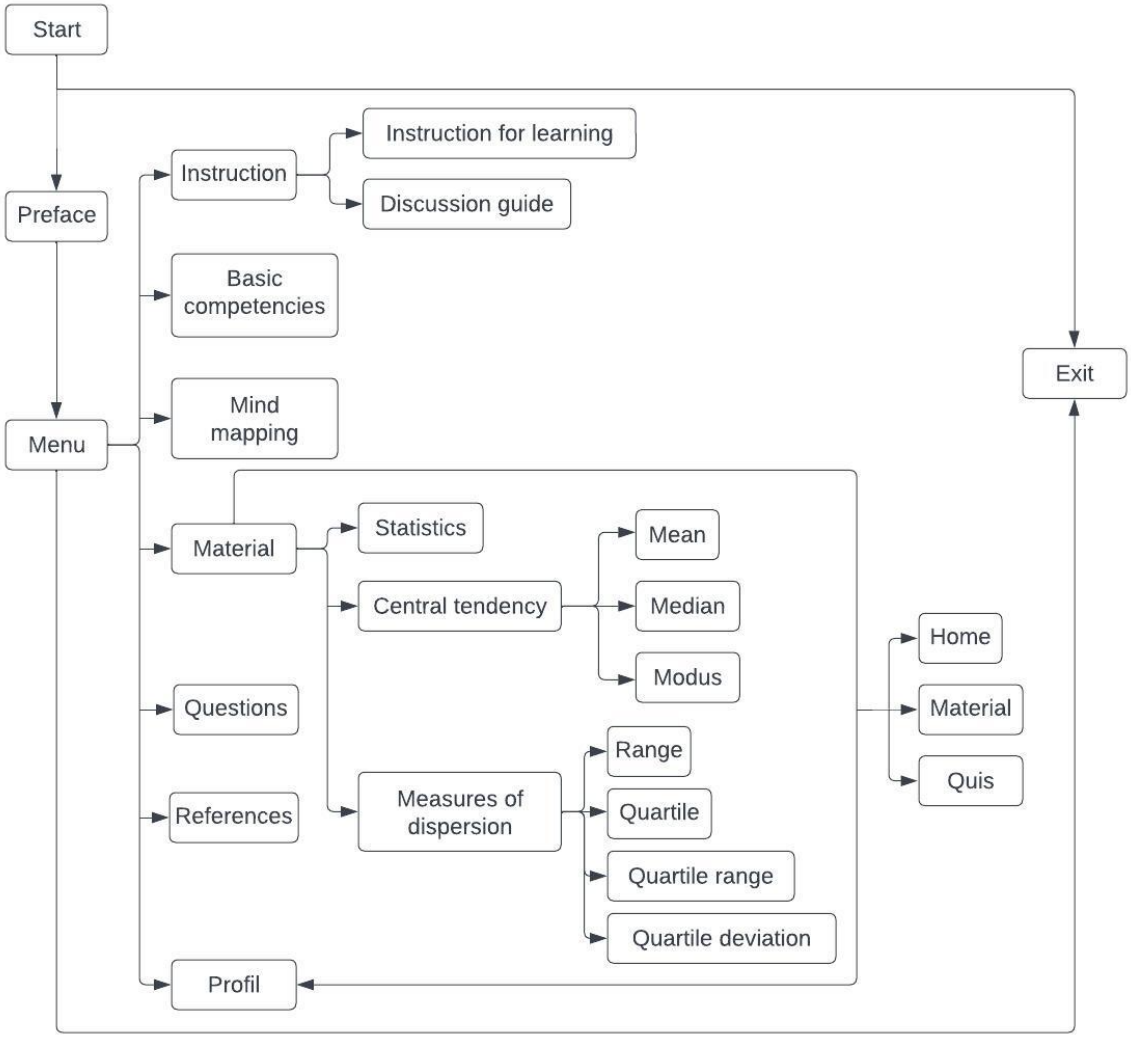

Figure 1. The Navigation Structure Design

Modules that have been designed at the design stage, then validated and carried out practicality tests. This activity is hereinafter referred to as the development stage. Validation of the statistics module was carried out by 3 (three) people with the results as shown in Table 4.

Table 4. Validation Results Data

Validator	Measured Aspects	Score	Suggestions
Validator of media	• Display • Programming	85,00%	• Consistent with the font used • Fix navigation buttons • Add a list of references
Validator of contents	• Learning • Content of the material • Language • The Question • Usability	87,50%	• Adapt sample questions to cases that students often encounter • There are still some non-standard words

Based on Table 4 and Table 1, the statistics module that has been developed is very valid. The module has also been practical based on practicality tests conducted on students. The results of the practicality test are shown in Table 5.

Table 5. Practicality Test Results Data

Measured Aspects	The Statement	Score
Display	The animations used are interesting	88,00 %
	The module display is attractive so it is not boring	
	The images used are clear and attractive	
	The navigation buttons are clear and easy to learn	
Material / Content	The material presented is easy to understand	92,00 %
	The material presented is interesting and fun	
	The clues and sentences are clearly stated	
Usability	This module makes it easy to understand statistical material	93,00 %
	This module is easily accessible and supports self-study activities	
	This module helps in studying statistical material	

The statistics module developed has been declared valid by experts and practical by students. Furthermore, it was tested on 12 students at MTs Keppe. This stage is hereinafter referred to as the implementation stage. From here, it is known the effectiveness of using the statistics module on student learning outcomes in statistical material. The trial was carried out directly by first providing an explanation related to the contents of the statistics module that had been designed. Student learning outcome scores can be seen in Table 6.

Table 6. Student Learning Outcomes Score

Student Name	Score			Sum
	I	II	III	
ZF	25	40	20	85
RY	40	40	5	85
NR	25	40	5	70
NH	40	40	20	100
RIRP	40	40	20	100
NRI	40	40	20	100
ARA	40	40	20	100
MM	40	40	15	95
DRA	25	40	5	70
AH	35	40	15	90
ARN	40	40	20	100
RS	40	20	20	80
Average				89,58

Based on Table 6, there are 10 students who have achieved scores above 72 or equivalent to 83.33%. Based on Table 2 and effective criteria, the statistics module that has been applied is declared effective in improving student statistics learning outcomes with an average score of student statistics learning outcomes of 89.58.

Furthermore, formative and summative evaluations of the statistics module were carried out. Formative evaluation has been carried out at every stage of development by adjusting the development of the statistics module to the TPACK concept. The statistics module developed has fulfilled the technological aspect (TK) because the module has been based on Android and can be accessed anytime and from anywhere via mobile phone. This module has also fulfilled pedagogic aspects (PK) because its presentation has been adapted to the RME approach, which can help students build their own understanding through exploration, manipulation of physical objects or visual representations, critical thinking through examples of given problems, and collaborating with classmates (Ananda, 2018). In addition, this module has also fulfilled the content or material aspect (CK) because the existing module has described statistical material adapted to the 2013 Curriculum. Summative evaluation is carried out based on expert assessment at the validation stage and practicality test whose results can be seen in Table 4 and Table 5.

4. Conclusion

This article has show the development of a statistics module using ADDIE. The mathematics module is produced in the form of an Android-based application that has been valid by validators and practical by the junior high school students in Keppe Luwu Regency, South Sulawesi. This module has also been tested for use and is effective in improving student statistical learning outcomes. This module can still be developed by adding an interactive exercise column and integrated with a recap of student evaluation results.

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